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STEEL SEA-GOING SHIP CONSTRUCTION STANDARDS (KANG-CHIH HAI-CH'U--ETC(U)
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BOOK VI WELDING AND RIVETING

Chapter I General Provisions

1.1.1 The present book applies to welding of ship hulls, steam boilers, pressure vessels, and major machinery and piping systems, and riveting of partial welded hull structures specified in "Steel Sea-going Ship Construction Rules."

1.1.2 In selecting welding methods, in addition to the manual electric arc weld, automatic and semi-automatic welding under the flux layer, other welding methods that satisfy the requirements of the welded joints specified in this book can also be used.

1.1.3 During hull construction, steel materials selected for use that are not within the range area specified in Book VII should be subjected to welding test for proper welded joint properties as required in accordance with the present book. Report of the qualifying test should be submitted to the Ship Inspection Bureau for approval before they can be used.

Chapter II Welding Materials

Section 1 General Rules

Materials

2.1.1 Welding materials for low and medium carbon steel and for low alloy structures must meet the requirements specified in this chapter and must have the complete testing documentation.

2.1.2 New welding materials for hull construction must be certified by the departments concerned, and agreement must be obtained from the Ship Inspection Bureau.

2.1.3 Examination and reexamination of welding materials must be carried out in accordance with the requirements specified in Chapter I and II of Book VII.

Dimensions of Specimens and Testing Methods

2.1.4 Dimensions and testing methods of specimen process of testing items specified in this chapter must be in accordance with the requirements concerned as specified in Book VII.

Section 2 Welding Rods for Manual Electric Arc Welding

Quantity

2.2.1 Each batch of welding rods must be fabricated from the same batch of materials of the same core and coating using the same manufacturing technique. The quantity of each batch generally should not exceed 30 tons.

Specimens

2.2.2 Welding specimens should be obtained according to the following requirements:

(1) Welding plates for specimens should be flat and the various mechanical properties testing should be taken from three samples according to Figure 2.2.2(1) below:

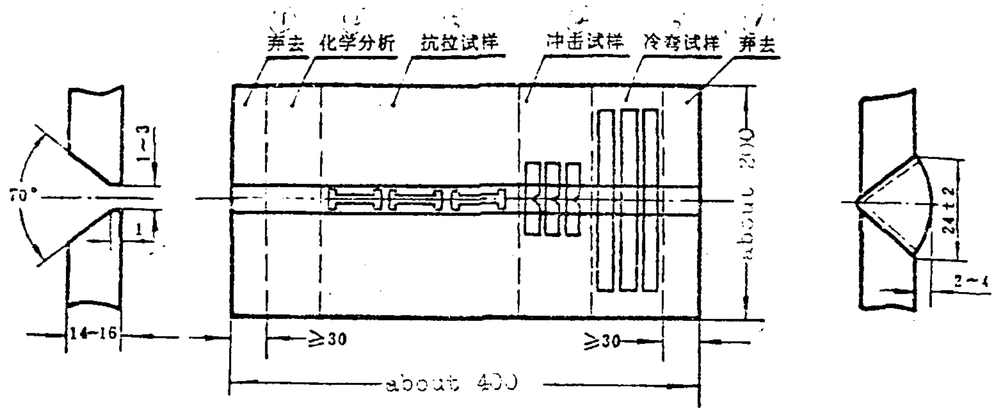


Figure 2.2.2(1)

(1) Discard
(2) Chemical analysis
(3) Tensile specimen
(4) Impact specimen
(5) Cold bending specimen

(2) Parent metals and Grade 1 and 2 welding rods for testing should be of carbon steel that meet the requirements of Class I hull structure use as specified in Chapter III of Book VII; Grade 3, 4 and 5 welding rods should be of carbon steel or equalant materials for Class III hull structure use.

(3) Welding rods that either use d.c. or a.c. source for welds, a.c. source should be used.

(4) Tensile specimens of deposited metals and cold bending specimens of welded joints can be subjected to deoxygenation treatment for 3 to 6 hours under temperature of 250°±10° C before testing.

2.2.3 Specimens made from the downhand position to be welded and their mechanical properties and chemical composition of deposited metals and welded joints should meet the requirements specified in Figure 2.2.3 below:

Table 2.2.3

焊条等级 (1)	Mechanical Properties (not less than) 熔敷金属抗拉强度 (kg/mm²)	熔敷金属延伸率 δ_5,%	熔敷金属冲击韧性 (kg-m/cm²)	对接接头冷弯角度	Chemical Composition S % (不大于)	P	适用于本规范第七篇第三章船体结构用钢材的级别 (3)
1	42	23	20℃,8.0	d = 2a 160°	0.040	0.040	碳素钢I级
2			−40℃,3.0				碳素钢I、II、III级
3			40℃,5.0				碳素钢I、II、III、IV级
4	50	21	−40℃,5.6	d = 3a			第一类低合金钢
5	55	19	−40℃,6.0	160°			第一、二类低合金钢

(1) Grade of welding rods (2) Tensile strength of deposited metals
(3) Extension ratio of deposited metals (4) Impact strength of deposited metals
(5) Cold bending angle of welded joints

(6) Applies to various classes of steel materials for use in hull structures specified in Chapter 3, Book VII.
(7) Hull structure carbon steel Class I
(8) Hull structure carbon steel I, II, and III
(9) Hull structure carbon steel I, II, III, and IV
(10) First category low alloy steel
(11) First and second category low alloy steel

Hot Cracking Test

2.2.4 Hot cracking test should be carried out according to the requirements listed below:

(1) Thickness of specimen plates should be in accordance with Table 2.2.4(1) below:

Table 2.2.4(1)

Diameter of welding rods (mm)	Thickness of steel plates (mm)
3.2, 4.0, 5.0	8~12
6.0	12~16

(2) When welding specimens, a single-level tee-joint is first welded on one side, with the height of its leg equal to 2 to 2.5 times the diameter of the welding rod; then within 4 to 5 seconds, the tee-joint is immediately welded on the other side, with its welding direction in the opposite direction of the first side, with the height of its leg equal to 1 to 1.5 times the diameter of the welding rod. The sides are to be welded with the maximum electric current as proposed in the explanation book for testing welding materials.

(3) After cooling the specimens, grooving is made at the center of the bed or bottom plate, cutting off the weld in the direction of the arrow as shown in Figure 2.2.4(3). There should be no hot crackings shown on the cross section of the two angular welding seams (having oxidized colors).

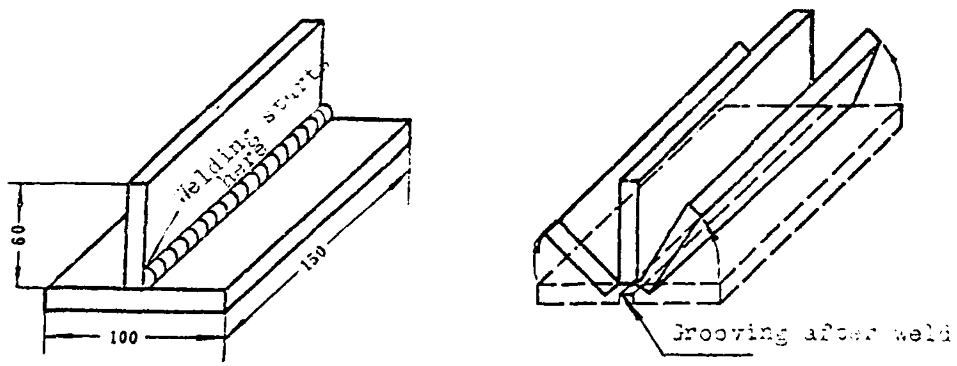


Figure 2.2.4(3)

(4) If the quality of the welding materials manufactured by the welding materials plants is good and stable, this testing may be omitted with approval of the Ship Inspection Bureau.

2.2.5 Alkaline, low-hydrogen welding rods should be used for welding the following hull structures and parts:

(1) All ship hull welding using low-alloy steel plates;

(2) Back-up circular butt weld of ship hull of carbon steel and butt weld of girder;

(3) End seams and side seams of shell plating in the ice belt location;

(4) Corner weld of sheer strake of the length of the ship greater than [illegible] m and corner weld of strength deck side plates within 0.5L amidship;

(5) Mast stems, derrick booms, and lifeboat gears and other components subjected to heavy loads;

(6) Towing hook stands;

(7) Main engine seating and its connecting components;

(8) Steam boilers and Grade 1 and 2 pressure vessels;

(9) Stems, sternposts, and transoms;

(10) Machine parts of changing load, impact load, and heat stress.

Section 3 Welding Strips and Flux of Automatic and Semi-automatic Welding under the Flux Layer

Chemical Composition

2.3.1 Chemical composition of welding strips must meet the requirements specified in Table 2.3.1. [next page]

2.3.2 Chemical analysis specimens of welding strips should be taken from 3% of each batch according to the number of bundles (but not less than two bundles), taken from the two ends of the welding strips of each bundle. Analytical results for C, S, and P should be certified according to the composition of each end of the strip, and the results of the other elements should be taken from the average value of the two ends of the welding strips. If the analytical results have an item that does not qualify, retesting of the unqualified elements is permitted, using twice the amount of the specimens among the unanalyzed strips. Those that are still not qualified should have the unqualified chemical contents of each bundle analyzed, selecting those that do finally qualify for use.

2.3.3 Concerning the carbon structural welding strips, if the manufacturing plant can definitely certify that the chemical contents of Si and Mn meet all the specified requirements, only the analysis of the contents of C, S, and P is required.

Table 2.3.1

Types of Welding Strips		Element contents C	Mn	Si	Cr	Ni	% S 不大于	P 不大于
炭素结构钢 (1)	H08	≤0.10	0.30~0.55	≤0.03	≤0.15	≤0.30	0.04	0.04
	H08A	≤0.10	0.30~0.55	≤0.03	≤0.10	≤0.25	0.03	0.03
	H08Mn	≤0.10	0.80~1.10	≤0.03	≤0.15	≤0.30	0.04	0.04
	H08MnA	≤0.10	0.80~1.10	≤0.03	≤0.10	≤0.25	0.03	0.03
低合金结构钢 (2)	H10Mn2	≤0.12	1.50~1.90	≤0.03	≤0.20	≤0.30	0.04	0.04
	H10MnSi	≤0.14	0.80~1.10	0.60~0.90	≤0.20	≤0.30	0.03	0.03
	H08Mn2SiA	≤0.10	1.8~2.1	0.70~0.95	≤0.20	≤0.25	0.025	0.025

(1) Carbon structural steel (2) Low alloy structural steel

Other

2.3.4 The combination of flux and welding strips is determined according to the mechanical properties of the different parant metals. The tensile strength, bendover point, extension ratio, and impact toughness of the deposited metals of the result of the combination as well as the cold bending angle of butt welded joints should meet the same requirements for manual arc welding strips.

2.3.5 Welding strips that either use d.c. or a.c. source for welds--welding flux combination, should use a.c. source during testing.

2.3.6 Dehydrogenation treatment of tensile test specimens of the deposited metals and the cold bending specimens of butt joints should be carried out in accordance with Section 2.2.2(4) of this chapter.

Chapter 3 Welding Methods for Hull Structures

Section 1 Butt Welding

Bevel Types

3.1.1 In welding materials with a thickness equal to or less than 6 mm, if they are definitely weldable with full penetration, may be welded without beveling the abutting plate; materials with a thickness exceeding 6 mm should be prepared for welding according to different welding process, may be welded by the single beveling or double beveling method. Bevel types may be determined according to the work situation.

3.1.2 If the welding process selected can insure full-penetration welds of the entire thickness, bevel types are not limited by the requirements specified in Section 3.1.1.

Sealing Weld

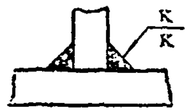
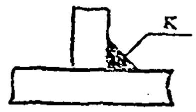
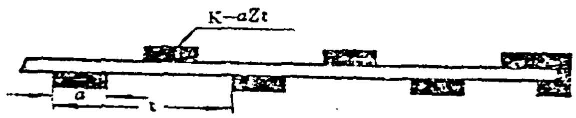
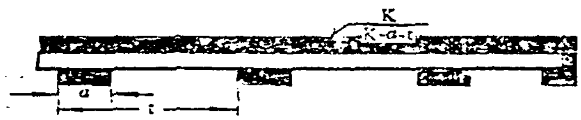
3.1.3 In addition to the special double beveling weld technique, other methods for butt welding should include the sealing weld.
When it is determined that sealing weld cannot be carried out, the back-up welding process may be used to insure full penetration of the thickness.

Section 2 Corner Weld

Method

3.2.1 Corner weld for hull structures, in addition to other special requirements, can generally be selected for use according to Table 3.2.1 below:

Table 3.2.1

No.	Corner Weld Method	Weld Symbols
1	Double Continuous Weld	
2	Single Continuous Weld	
3	Double Intermittent Weld	
4	One side with continuous weld One side with intermittent	

Note: If single continuous weld is used, the quilting tack weld and the single continuous weld joint should not be on the same side of the structure.

Scalloped Intermittent Fillet Weld

3.2.2 If No. 4 or No. 5 weld in Table 4.1.3(2)(2) of this Book is used, the double scalloped intermittent fillet weld can be used as a substitute, with the sizes of the scallops as specified in Fig. 3.2.2 below: The two ends of the scalloped intermittent fillet weld should have good quality fillet corner welding.

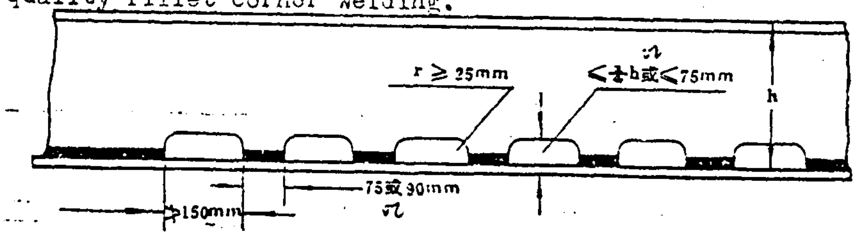


Figure 3.2.2

Areas for scalloped intermitten fillet weld may be determined according to work design, but the following areas should not use scalloped intermitten fillet weld:

(1) Within the area 0.25L from the stern and within the aft peak;

(2) Within components having greater rigidity;

(3) The entire bracket, and ends of beams, frames, longitudinals, and stiffeners, and within area 250 mm from the two sides where the components intersect.

Section 3 Lap Weld

Applicable Range

3.3.1 Lap weld should not be used for welding major structures of ship hull; butt weld should be used.

Lap Weld Width and Welding Dimensions

3.3.2 If lap weld is used, its lap with b should meet the requirements listed below; also, the welding dimensions of the two jointed surfaces of the lap weld should be in accordance with the requirements of the No. 1 weld specified in Table 4.1.3(2)(a), where $b = 2\delta + 15$ mm; but should not be greater than 50 mm.

In the above formula, δ = the thickness of the thinner block plate of the lapped joint.

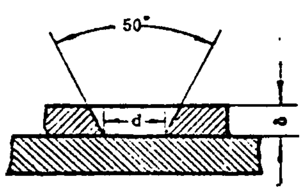
3.3.3 The lap width of the shell plate and the forged steel sternpost should be specially considered.

Section 4 Plug Weld and Spot Weld

Plug Weld

3.4.1 Under special condition when plug weld is selected for use, it is suggested that such welds may be spaced according to the dimensions specified in Figure 3.4.1, in order to satisfy the requirements of sufficent root penetration.

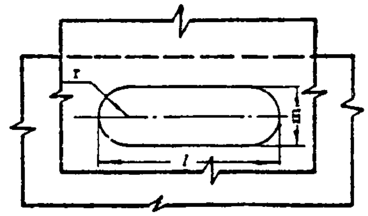
Circular Plug Weld



$d = 2\delta$

when $\delta < 8$mm, do not punch holes

Slot Weld



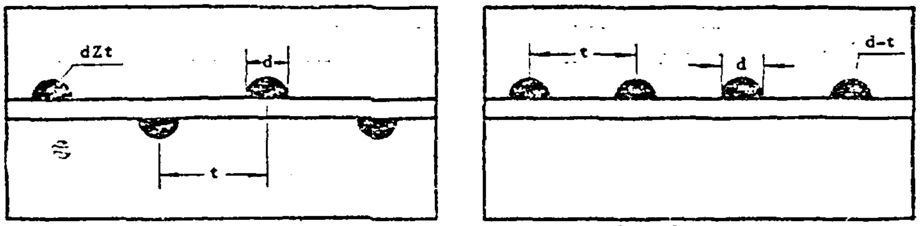
$r = \delta$, $m = 2\delta$

l- can be determined according to design

Figure 3.4.1

Spot Weld

3.4.2 When spot weld is used for welding secondary structures with plates having a thickness less than or equal to 5 mm, its spot weld diameter d and spot weld distance t should satisfy the requirements specified in Figure 3.4.2 below: Spot weld types may be either single surface or double surface intersecting.



Double surface intersecting spot weld d = 10mm t ≯ 5δ Single surface spot weld

Figure 3.4.2

Chapter IV Welding of Hull Structure

Section 1 General Rules

Structure

4.1.1

(1) In the various welded structures, welded joints arranged in the area where stress concentrates should be avoided; the place where sections of members change abruptly should have a sufficent transition area.

(2) In various welds, manual, automatic or semiautomatic welding of downhand welding position should be considered for use within the maximum range possible during welding operations.

(3) Horiztonal welds for major hull structures should maintain a fixed distance. Horiztontal distance for butt welds should not be less than 100 mm, and pointed angle formations should be avoided. The horizontal distance between butt welds and corner welds should not be less than 50 mm.

(4) In butt welding materials with different thickness, when the thickness is greater than or equal to 4 mm, the edges of the plate should be scarfed, making it to have a homogeneous transition. The width of the scarf should not be less than 4 times the thickness.

4.1.2 Welding Preparation

(1) Before welding, the oxidized splinters, moisture, oil pollution and other pollutents that might affect the quality of the weld should be removed from the groove edges of the welded parts.

(2) Groove types and fitting gaps of the welded edges should meet the requirements specified on design drawings. Tack welding that might affect the quality of weld and edge defects should be removed or correct before welding operations.

(3) When welding low-alloy steel parts or parts with strong rigidity under low temperature conditions, effective pre-heating and thermal protective operations should be practiced.

4.1.3 Types and Scantlings of Corner Weld of Hull Structures

(1) Weld leg scantlings of corner welds should be determined according to the thickness of the structural part's thinner plate.

(2) Corner weld types and scantlings of dry cargo ship hull structures should be in accordance with those specified in Table 4.1.3(2)(a) and Table 4.1.3(2)(b).

(3) Corner weld types and scantlings of tanker hull structures, except those of oil tanks, which should be in accordance with those specified in Table 4.1.3(2)(a) and Table 4.1.3(3), should meet the requirements specified in Table 4.1.3(2)(a) and Table 4.1.3(2)(b).
Scantlings of weld legs of corner welds for oil tank deck structure of tankers should be in accordance with the requirements specified in Table 4.1.3(2)(a), with an additional 1 mm in thickness for corrosion replacement.

(4) Corner weld types and scantlings of passenger ship hull structures should be in accordance with those matching items specified in Table 4.1.3(2)(a) and Table 4.1.3(2)(b).

(5) Girders, frames, strength transverse beams, and ends and knee areas of longitudinal cut-off sections of various ship hull structures should have double continuous strength weld in accordance with the required dimensions specified in the present Section 4.1.4.

(6) When the difference of the thickness of the jointed parts is too large, their corner weld types and scantlings should be specially considered.

Corner Weld Methods and Scantlings   Table 4.1.3(2)(a)

焊缝号 / 焊缝型式 / 板厚 (mm)	1	2	3					4					5		
	$\frac{k}{k}$	$\frac{k}{k}$	k—azt		可代用的型式			k—azt		可代用的型式			k—azt		可代用的型式
			k	azt	$\frac{k}{}$	$\frac{k}{k}$	$\frac{k}{k\text{-}a\text{-}t}$	k	azt	$\frac{k}{}$	$\frac{k}{k}$	塞孔焊	k	azt	$\frac{k}{}$
≤4	8	8	8					8					8		
5—6	4	8	4		4	8		5		8			5		3
7—8	5	4	5		5	4	$\frac{4}{4\text{-}75\text{-}300}$	6		4			6		[illegible]
9—10	6	5	6		6	4	$\frac{5}{5\text{-}75\text{-}300}$	7		5	4	6	7		[illegible]
11—12	7	5	7		7	5	$\frac{6}{6\text{-}75\text{-}300}$	8		5	5	7	8		[illegible]
13—14	8	6	8	75Z150	8	5	$\frac{7}{7\text{-}75\text{-}300}$	9	75Z250	6	5	8	9	75Z300	5
15—16	8	6	9			6		10			6	8			
17—18	9	7	10			6		11			6	9			
19—20	10	8	11			7		12			7	10			
21—22	11	8	12			7		13			7	11			
23—26	12	9	13			8		14			8	12			
27—30	13	10	14			9		15			9	13			

1. Thickness of Plate
2. Weld Method
3. Weld Number
4. Substitute Method
5. Slotted Weld

Note: (1) Intermitten weld specified in the above Table can be converted into other required intermitten weld according to the formula below, but the distance of the cross section of the weld should not be greater than 300mm; the length of the cross section, a, should not be less than 75 mm.

$$K = K_0 \frac{t}{t_0} \quad \text{mm}$$

In the formular above, where

K_0 — the height of weld leg specified in the Table;

t_0 — the distance of the cross section of the weld specified in the Table;

K — converted height of weld leg;

t — Converted distance of the cross section of the weld.

(2) When the thickness of the plate is greater than 15mm, the selected No. 5 weld should be changed to the No. 4 weld.

Welding Numbers of Corner Weld of Dry Cargo Ship Hull Structures

Table 4.1.3(2)(b)

Joint Number	Name of Jointed Parts			Welding Number	Remarks
	Double Bottom				
1	Center girder double plate	Flat keel	Watertight sections	1	
			Non-watertight sections	5*	
		Tank top plate	Watertight sections and engine compartment area	1	Engine base plate should be in accordance with requirements of Section 4.2.3 of this book.
			Other areas	3	
		Floors	Main engine seating and under axial bearing seat	1	
			In area 0.25L from stem	2	
			Other areas	3*	
		Watertight floors		1	
2	Side girder double plate	Bed plate	Engine compartment and area 0.25L from stem	3	
			Other areas	5	
		Tank top plate	Under the axial bearing seat	2	
			Engine compartment area	3	
			Other areas	5	
		Floors		4*	
3	Girders and stiffening webs			5	
4	Floors	Sides of watertight and oiltight floors		1	
		Bed plate	Aft peak and area 0.25L from the stem	3	
			Other areas	5	
		Tank margin plate	In area 0.25L from stem	1	Horizontal and bottom tank margin plates are the [illegible]
			Other areas	2	
		Tank top plate	Main engine seating and under the axial bearing seat	2	
			In area 0.25L from stem	4	
			Other areas	5	
		Stiffening webs		5	

Table 4.1.3(2)(b) Cont.

Joint Number	Name of Jointed Parts			Welding Number	Remarks
5	Pipe tunnel floors	Fore and aft web			Same as center girder double plate and floors
		Tank top plate, bed plate		3	
		Face plae		5	
6	Tank margin plate	Inner bottom		1	
		Shell plate		1	or in accordance with requirement specified in Section 4.2.4 of this book.
7	Longitudi-als	Tank top plate		5	
		Bed plate	In area 0.25L from stem	4	
			Other areas	5	
	Single Bottom				
8	Center keelson double plate	Flat-plate keel	In area 0.25L from stem	2	
			Other areas	3	
		Floors		1	
		Transverse bulkhead		1	
		Face plate	In area 0.25L from stem and engine compartment area	3	
			Other areas	4	
9	Side keelson double plate	Bed plate	In area 0.25L from stem and engine compartment area	3	
			Other areas	5	
		Face plate	Under axial bearing seat	2	
			Engine compartment area	3	
			Other areas	5	
		Floors		4*	
10	Floors	Bed plate	In area 0.25L from stem and deep water tank, afterpeak	3	
			Other areas	5	
		Face plate	Under axial bearing seat	2	
			In area 0.25L from stem and e engine compartment area	3	
			Other areas	5	

Table 4.1.3(2)(b) Cont.

Joint Number	Name of Jointed Parts			Welding Number	Remarks
Side Framing					
11	Strength frame double plate	If deck frames have clamped-free beams			See Joint No. 2 of this table
		Shell plate	In area 0.25L from stem and deep tanks	3	
			Other areas	4	
		Shell (side) longitudinals		1	
		Face plate		4	
12	Side longitudinal double plate	Bulkheads		1	
		Shell plate	In area 0.25L from stem and deep tanks	3	
			Other areas	4	
13	Main frames and shell plate	Deep tanks, oil tanks and in area 0.25L from stem		4	
		Other areas	At distance where the frame ≤850 mm	5	
			At distance where the frame >850 mm	4	
	Deck frames and shell plate			5	
14	Tank side bracket	Inner side plate		2	
		Shell plate		2	
		Face plate		3	
Deck					
15	Deck	Transverses		4	
		Longitudinals		5	
16	Strength transverse double plate	Deck		3	
		Face plate		4	
		Longitudinals		2	
17	Deck longitudinal double plate	Deck		3	
		Face plate		4	
		Transverse bulkhead		1	

Joint Number	Name of Jointed Parts			Welding Number	Remarks
18	Strength deck side plate and sheer strake			1	Ships with length >60m, area 0.4L amidship in accordance with requirements specified in Section 4.2.2 of this book.
19	Other deck side plate and shell plate			2	
20	Overhanging beam or overhanging longitudinal double plate	Deck, shell plate		2	
		Hold stringer or hatchway-end beams		1	
		Face plate		3*	
	Side Water Tanks				
21	Diagonal top plate of bottom hold and tank top plate, shell plate				1. Transverse framing is the same as Joint No. 4 and 6; 2. Longitudinal framing is the same as Joint No. 22.
22	Top side tanks	Diagonal bed plate and deck, shell plate		1	
		Longitudinals	Deck	3	
			Shell plate	4	
			Diagonal bed plate	5	
		Strength frame double plate	Deck, Shell plate	3	
			Face plate	4	
	Hatches				
23	Coamings	Deck	Deck opening corner	1	
			Other sections	2	
		Stiffeners	Verticle (brackets)	4	
			Horizontal (face plate,	2	

Joint Number	Name of Jointed Parts			Welding Number	Remarks
24	Hatchway-end beams		Deck	2	
			Face plate	4	
25		Shifting transverse beams and their face plate		4	
26	Steel hatch covers	Frames	Frames	2	
			Shutter	4	All sides must be continuous welded
	Bulkheads, Platforms, Shaft Alleys				
27	Bulkheads	Boundaries	Watertight	1	
			Non-watertight	3	
		Girders (longitudinals and face plate)		4	
		Stiffeners		4	
28	Platforms	Shell plate or bulkheads	Watertight	2	
			Non-watertight	3	
		Transverses (beams and face plate)		4	
29	Shaft alleys	Boundaries		1	
		Stiffeners		4	
		Stiffeners and face plate		5	
	Engine Seatings				
30	Main engine seating girders	Face plate (tank top plate,			According to requirements of section [illegible] of this book.
		Bed plate, floors and other components		1	
31		Propulsion boiler casings and tank top plate, face plate, floors		1	Auxiliary boiler casings may be welded using No. 2 weld.
32		Auxiliary machinery seatings and shell plate, tank top plate, deck, face plate			Includes diesel generator group, air pressure group and deck machinery.

Table 4.1.3(2)(b) Cont.

Joint Number	Name of Jointed Parts		Welding Number	Remarks
	Pillars			
33	Double plate and frames		3	
34	Pillars	The two ends	1	
		Brackets	2	
	Deckhouses			
35	Outside tank bulkheads	Strengthened decks	2	Angular double plates should be the same
		Other upper decks	3	Should be of continuous weld on one side, intermitten weld on the other.
36	Inside tank bulkheads	Strengthened decks	3	The side containing water within the area with a height of 300 mm under the lower side of the bulkheads, galley, pantry, laundry room, shower, latrine, and battery room.
		Other upper decks	4	
37	Engine compartment tank bulkheads	Strengthened decks	2	
		Other upper decks	3	Should be of continuous weld on one side, intermitten weld on the other
38	Decks of various level, transverses and longitudinals		5	When $\delta<5mm$, carry out spot weld according to requirements of Section 3.4.2 of this book.
39	Tank bulkheads and stiffeners		5	Ditto

Joint Number	Name of Jointed Parts			Welding Number	Remarks
	Bulwarks				
40	Brackets	Bulwark plate	With hoisting rings	2	
			Without hoisting rings	3	
		Deck	With hoisting rings	1	
			Without hoisting rings	2	
41	Bulwark plate and stiffeners			5	
	Rudder				
42	Lattrice plates	Top and bottom bearings (rudder carrier bearings)		1	
		Lattrice plates		2	
		Bosom plates		3	
43	Rudder Plates	Bosom plates		Plug weld	In accordance with requirements of Section 3.4.1 of this book.
		Crown plates, bed plates, guide plates and verticle lattrice plates substituing for the lower rudder stock.		1	
	Brackets				
44	Various brackets			1	

Note: (1) Double continuous strength weld should b carried out for ends of girders, floors, strength transverse beams and longitudinals and bracket areas in accordance with requirements specified in this Section 4.1.4.

(2) * Should use double continuous weld during welding operations.

Corner Welding Numbers for Oil Tank Structures of Tanker Ship Hull

Table 4.1.3(3)

Joint Number	Name of Jointed Parts			Welding Number	Remarks
	Bottom structures				
1	Center keel double plates	Flat-plate keel	$L < 90$ m	2	
			$L > 90$ m	1	
		Transverse bulkheads		1	
		Floors		1	
		Tripping brackets		4*	
		Face plates		3	
2	Side keel double plates	Bed plates		2	
		Brackets		2	
		Face plates		4	
3	Brackets	Bed plates		2	
		Longitudinal bulkheads		1	
		Face plates		3	
		Stiffening webs		4	
4	Longitudinals and bed plates			3*	
	Side structures				
5	Strengthen frame web plate	Shell plates	Web plate height $\leq$1000mm	2	
			Web plate height $>$1000mm	1	
		Side girders		1	
		Face plates		4	
		Stiffening webs		4	
6	Frames and shell plates			3*	

Joint Number	Name of Jointed Parts			Welding Number	Remarks
7	Side girder double plates	Shell plates	Web plate height	2	
			Web plate height	1	
		Transverse bulkheads		1	
		Face plates		4	
		Stiffening webs		4	
8	Longitudinals and shell plates			3*	
9	Martingale ends			1	
	Bulkhead structures				
10	Sides of longitudinal and transverse bulkheads			1	
11	Verticle girder webs	Bulkheads		2	
		Face plates		4	
12	Horizontal girder webs	Bulkheads		2	
		Face plates		4	
13	Verticle girders and horizontal girders			1	
14	Stiffeners and bulkheads of longitudinal and transverse bulkheads			4	
	Deck structures				
15	Strength transverse beam webs	Decks		2	
		Longitudinal bulkheads		1	
		Deck girders		1	
		Face plates		3	
		Stiffening webs		4	
16	Girder webs	Decks		2	
		Face plates		3	
		Stiffening webs		4	

Table 4.1.3(3) Cont.

Joint Number	Name of Jointed Parts	Welding Number	Remarks
17	Deck side plates and sheer strakes	1	Ships with length [illegible] m, area 0.4L amidship should be in accordance with requirements of Section 4.2.2 of this book.
18	Longitudinals and decks	3*	

Note: (1) Double continuous strength weld should be used for ends of cross sections of girders, floors, strength transverse beams and longitudinals and bracket areas in accordance with requirements specified in the present Section 4.1.4.

(2) * Except for coastal area tankers which may use the intermitten weld, other tankers should use the double continuous weld.

Strength Weld

4.1.4 When intermitten weld or single continuous weld is selected for use in welding various structures, double continuous strength weld may be used in welding the ends of components in accordance with the required lengths described below:

(1) Corner weld for webs and face plates of built-up girders, strength transverse beams, and strength frames should be double continuous weld in the bracket area.

(2) Strength weld lengths of ends of girders, floors, strength transverse beams, and strength frames should not be less the height of the webs. However, side girder ends of intercoastals may be reduced.

(3) Strength weld length of the cross sectional ends of longitudinals should not be less than one frame space.

(4) When chamfering the ends of frames, its strength weld length should not be less than the chamfering length; when the ends of frames are fastened by welding, their strength weld lengths should not be less than the height of the frames.

(5) Strength weld used for connecting brackets to the ends of frames, beams, and stiffeners should be continuous weld on one side of the bracket area. The fillet corner weld length of the ends of the other side should not be less than the height of the frames, and should not be less than 75 mm.

(6) Fillet corner weld should be carried out for welding the two ends of straight cut, angular cut, and hole openings (such as flood holes, air holes ,) of various component members according to the lengths described below:

When thickness of plate >12mm , fillet corner weld length $\nless$ 75mm;

When thickness of plate $\leqslant 12$mm , fillet corner weld length $\nless$ 50mm.

(7) The two sides of butt joints of various components should have one section with symmetric corner weld, its length should not be less than 75 mm.

4.1.5 If component members pass through watertight or oiltight bulkheads, in addition to welding compensating plates at the bulkheads, a watertight welded section should be added in accordance with Figure 4.1.5 after holes are slotted, to insure watertightness of the bulkheads.

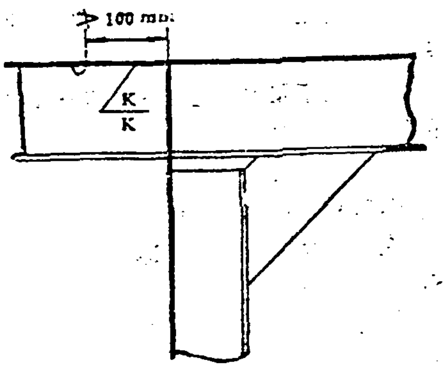


Figure 4.1.5

Section 2 Welding of Main Joints in Hull Structures

Stemposts, sternposts, rudder stocks, and stern shafts

4.2.1 Welding of stemposts, sternposts, rudder stocks, and stern shafts:

(1) Casting and forged matials for use should meet the requirements specified in Book VII.

(2) If the weld members contain carbon greater than 0.23 or having strong rigidity, corresponding preheating and thermal protection practices should be carried out before and after welding.

(3) In using manual welding to weld stemposts, sternposts, rudder stocks and stern shafts, tempering treatment should be carried out if necessary. In using electroslag welding to weld stemposts, sternposts, rudder stocks and stern shafts, normalizing and tempering treatments should be carried out after welding.

If the stempost, sternpost and rudder stock components are too large, and heat treatment of the entire component is difficult, effective partial heat treatment methods may be used.

(4) Welded joints should be subjected to flaw detection inspection. Welded internal parts should not have any fracture, unpenetrated welding and other defects affecting strength.

Sheer strakes and strength deck side plates

4.2.2 Welding of sheer strakes and strength deck side plates:

(1) In welding sheer strakes and strength deck plates, if T-butt corner weld is used and when the length of the ship L is greater than 50 m, the strength deck plate edges within the area 0.5L amidship should be grooved without roots; groove types should be determined according to working conditions.

(2) In welding sides using the arc welding method, in addition to the jointed area of the arc sheer and corner weld in sheer that should have sufficient length of the transition area, the edges of the ends of the first corner welded deck plate should be suitable grooved, making the corner weld to have a smooth transition, with the depth of the grooves gradually passing from 2/3 thickness to 1/3 thickness. Arc and spot welding area of corner weld should have full penetration

Engine Casings

4.2.3 Welding of diesel engine seatings:

(1) When the thickness of the longitudinal plate of the main engine seating is greater than 12 mm, the jointed area of corner weld of the horizontal face plate and longitudinal should be faced with the edges of the longitudinal plate to grooved without roots; types of grooves should be determined according to working conditions. Outside dimensions of the two sides of the corner weld should be symmetrical.

(2) Corner weld for other components (such as bottom plates, floors, partition plates) that are connected with the main engine seating should be carried out in accordance with the No. 1 weld specified in Table 4.1.3 (1) (a) of this book.

(3) Welding of seatings of diesel engines with great horse power that do not belong to the described range specified in Section 17, Chapter I, Book I of the present Rules should be specially considered.

Small included angle corner joints

4.2.4 Welding of small included angle corner joints

In order to avoid welding difficulties, it should be considered during structural designs not to form any small included angles while carrying out corner welding operations. Under individual situation, if the included angle of the component is less than 50 degrees, welding may be carried out according to the methods described below:

(1) In corner welding bottom plates and side plates, if it meets the requirements indicated in Fig. 4.2.4(1), single continuous weld may be carried out on the side of the blunt angle. In welding the bottom plates, it is suggested to select welding rods with small diameter.

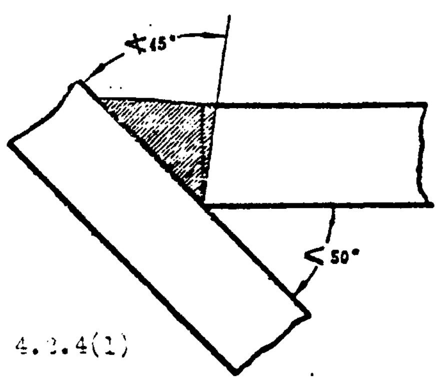


Figure 4.2.4(1)

(2) In corner welding brackets, if the above described situation is faced, welding on only one side of the blunt angle may also be carried out, but the two ends of the braocket should have sufficient long fillet corner weld.

Masts

4.2.5 Welding of Kingposts

(1) Welding for kingposts (Pillars) of derrick boom with a maximum safe load not exceeding 10 tons should meet each of the requirement described below:

(2) Kingposts fabricated from steel plates should used butt welding, also, the entire thickness should have full penetration.

(3) If the masts do not penetrate but welded on the strength deck plate, the lower of the mast should be single or double grooved without roots to insure complete penetration of the corner weld.

(4) If the masts do penetrate into the strength deck plate, the corner weld of the mast and the penetrated deck plate should use double continuous weld; corner weld of the lower ends of the masts and the deck plate should use single continuous weld, but should be grooved with suitable depth.

Chapter V Inspection of Hull Structure Welding

Section 1 Inspection of External Welding Quality

5.1.1 Surface of weld should be smooth, tight and should not have cracks, welding tumors, gnaws or bites, air holes, slag and dents. If the above mentioned defects exist, they should be repaired before inspection of internal welding quality and sealing tests occur.

5.1.2 Welding defects produced during sectional construction should be repaired repaired before it goes on the slipway; repairs should not be concentrated at the berth area.

Section 2 Inspection of Internal Welding Quality

5.2.1 After major hull welding is completed, in addition to the external quality inspection, in accordance with Section 1 of this chapter, internal quality inspection should be carried out according to the present section.

5.2.3 Ratio and qualifying grade levels of observation (or flaw detection) of major hull welding, except those of special requirement, should be in accordance with those specified in Table 5.2.3.

5.2.2 Inspection of internal welding quality inspection should be carried out by using radiographic observation, ultrasonic flaw detection or other effective methods.

Table 5.2.3

No.	Location of Inspection	Inspection Percentage	Qualifying Grade
1	Hull back-up circumferential weld	$L \geq 80$ m 5	2
2	Corner weld specified in Section 4.3.2(1) of this book		
3	Strength deck plate in area 0.5L amidship and welding of sheer strakes, bilge strakes, flat-plate keel	$L < 80$ m 3	
4	Other ship shell butt welds not specified in No. 3 of this table	2	3
5	Edge welding of engine compartment bed plates and enige seating face plates		
6	Butt welding of king posts	See note below	3
7	Hull welding of girders, longitudinals of strength deck plates and bottom plates	Spot check	3
8	Butt welding of other decks of various levels, platforms and longitudinal and transverse bulkheads		4

Note: Inspection location of masts should include each intersecting point of the circumferential weld, their lengths should not be less than 25% of the total circumferential weld length.

5.2.4 The length percentage ratio of the inspection of internal welding quality should be calculated according to the total length of the butt weld of major hull structures. Inspection ratios should be increased or reduced according to welding quality of the factories, welding techniques, materials and the degree of technical skill and experience, with the approval of the Ship Inspection Bureau.

5.2.5 The determined specified standards of inspection of internal welding quality should be the determined standards approved by the Ship Inspection Bureau.

5.2.6 The spot and lining types of defects discovered during welding inspection using the ultrasonic flaw detection method, in addition to satisfy the requirements specified in the present Section 5.2.5, should also satisfy the requirements described below:

(1) The two sides of the inspected welds should be rid of the oxidized splinters and metal cinters within the area of five times the thickness, to insure good contact of the detector and the inspected components.

(2) If there are doubts about the inspected welds, calibration should be carried out using radiographic observation.

5.2.7 If in the inspected welds, when the unpermitted defects are discovered to have possible extension, one end (or two ends) of the defects' extension direction should be reexamined, untile the weld of the adjacent area is qualified. After the internal defect of the unqualified weld is repaired, it should be reinspected by observation (or flaw detection).

Section 3 Welding Seal Tests

Testing Methods

5.3.1 After the construction of the ship hull is completed, welding seal tests should be carried out. Testing may be carried out using watertight, airtight, oiltight or equivalent and effective methods.

5.3.2 When watertight or airtight Testing is carried out with outside temperature lower than 5 degree C, heating operations should be carried out.

5.3.3 Airtight testing for hull structures with a thickness of [illegible] mm, if the strength permits, can substitute watertight testing; welding seal testing and structured strength testing may then be combined together and carried out. Testing pressure is generally [illegible]kg/cm^2 (but should not be less than [illegible]kg/[illegible]). Leaking inspection should be carried out after maintaining the above mentioned pressure of 15 minutes.

5.3.4 In designing hull structures that need strength testing, airtight testing can not be substituted for water pressure testing. However, if necessary, seal test may be carried out in advance. Water pressure testing may then then be specially carried out to inspect the structural strength.

Testing Preparation

5.3.5 Before ship hulls have been seal tested, paints or insulting materials should be applied to the watertight welds.

5.3.6 Ship hull seal testing should [illegible] in accordance [illegible] requirements specified in Table 5.3.6.

Table 5.3.6

No.	Name of tanks (or compartments)	Water Column Tests
1	Fore and aft peaks	
	Feed water tanks	Water column height to top of air pipe
	Fuel oil tanks	Water column height to top of tank above 2.5 m*
2	Double bilge tanks	Water column height to top of air pipe
3	Bottoms of single bottom ships	Water pouring height to keel plate
4	Freeboard side plates and decks	Flushing tests
5	Side tanks	Water column height to top of air pipe
6	Oil tanks of tankers and oil receiving deep tanks	Water column to top of tank above 2.5 m*
7	Water receiving deep tanks	Water column height to top of air pipe
8	Pump compartments	Water pouring height to full load waterline
9	Void compartments	Water column height to top of tank above 0.6 m
10	Bottom valve box	
	With no flushing installations	Water column height to bulkhead deck above 1 m
	With flushing installations	According to pressure of the flushing installations
11	Rudders, pipes	Water column height equals to 1.5 times the draft
12	Watertight components such as shaft alleys, bulkheads, decks, open portions and outside coamings of top deckhouses, watertight doors and windows, hatch coamings, hatch covers, etc.	Flushing tests
13	Galley, pantry, laundry room, shower, latrine, battery room, etc.	Under coamings, use water pouring tests, height to the threshold.

Note: (1)* Ships with a depth less than 5 m, height of water column above the deck may be 0.5 times the depth.

(2) Flushing tests should be in accordance with the following requirements: (1) Height from the testing spot to water spraying should be less than 1 m. (2) Nozzle diameter should not be less than 16 mm (3) Flushing distance should not be greater than 3 m.

Section 4 Technical Tests of Welded Joints

5.4.1 When special materials or welding technique are selected for used in hull structures, technical testing of the weld should be carried out, to determine the characteristics of the joints.

Performance Requirements

5.4.2 Results of technical tests of butt joints should be in accordance with the requirements specified in Table 5.4.2 below:

Table 5.4.2

Testing Items		Number of Specimens	Performance Requirements
Joint tensile		2	Tensile strength should not be lower than the lower value of the parent metal.
Cold bending		2	d=2a, * bending angle 180 degrees, no fracture
Low-temperature impact	Center of weld	3	Impact value should not be less than the lower value of the parent metal.
	Heat affected area	3	

Note: (1) Take the average value of 3 specimens for weld impact toughess testing, but the lowest value of one of the three should be not less than 80% of the requirement.

(2)* If the parent metal for testing is low-alloy steel, testing may be carried out according to the diameter d of the bend center.

5.4.3 If problems arise during testing of mechanical properties, the Ship Inspection Bureau may suggest other necessary items for supplementary testing.

5.4.4 If heterogeneous steel of differnet strength is used in welding joints, the characteristics of the joints should be examined according to the requirements of the lower grade of the parent metal,

5.4.5 Work demensions and testing methods of specimens for welding joint mechanical properties should be in accordance with requirements specified in Chapter II, Book VII.

Chapter VI Welding of Boilers and Pressure Vessels

Section General Rules

Types

6.1.1 This chapter applies to welding types of structures of boilers and pressure vessels in accordance with the requirements specified in Chapter III, Book II of the present Rules.

Selection of Materials

6.1.2 Materials selected for use in welding structure of boilers and pressure vessels should be in accordence with the requirements relating to materials specified in Book VII of the present Rules. When a special type of steel is selected for use, there should be a supplementary welding test to select the welding material.

Welding Methods

6.1.3 In welding boilers and pressure vessels, manual welding, automatic and semi-automatic welding under flux layer, or electroslag welding are generally selected for use. If other methods are selected for use, they must be approved by the Ship Inspection Bureau.

Section 2 Structures

Bending Edges

6.2.1 In jointing structures of boilers and pressure vessels, bending edge structures are generally selected for use.

6.2.2 Welding positions should not be arranged in the bending edge area. The distance of weld to the starting point of the bending edge should not be less than 2 times the thickness of the plate. Under individual situation and with the agreement of the Ship Inspection Bureau, welding at the starting point of the bending edge is permitted.

Butt Welding

6.2.3 Major welding for component members, besides the special requirements, should use butt welding.

6.2.4 When jointing components to make smooth transition with different thickness, in addition to the special requirements, chamfering is generally carried out according to the requirements specified in Section 4.1.1 of this Book.

Section 3 Fittings and Welding

Grooves

6.3.1 Edges of welding various components of boilers and pressure vessels should have quality grooves, and gaps. Tack welds that affect the welding quality should be spaded out before welding.

6.3.2 Preparation and cleaning works before welding should be in accordance with the requirements of 4.1.2 of this book.

6.3.3 In addition to the welding methods that are capable of welding in double formation, butt joints of other welding methods should have quality sealing weld. If because of the special condition exists in certain structures and that there is definitely no way to carry out sealing weld, welding with a back-up place is permitted, but the strength modulus of this type of weld should be in accordance with the requirements specified in Table 3.2.5 of Chapter III, Book II of the present Rules.

Drum Accessories

6.3.4 Short pipes and other accessories of drums of Class I and II boilers and pressure vessels generally use double continuous corner weld; they are also welded and installed before heat treatment.

Defect Repairs

6.3.5 Outside and inside defects of welds should be repaired before heat treatment.

Section 4 Heat Treatment

6.4.1 Heat treatment should be carried out after the completion of weld in boilers and pressure vessels, to eliminate stress. With regard to the fire-tube boiler drums with large diameter and that there is definitely no condition under which to carry out heat treatment for the entire component, partial heat treatment may be carried out, with the agreement of the Ship Inspection Bureau.

6.4.2 If the steel materials for fire-tube boilers, auxiliary boilers, and Class I pressure vessels contain not more than 0.24% carbon, and the welding strength modulus had been selected according to Table 3.2.5 of Chapter III, Book II, heat treatment may be omitted after welding. However, heat treatment for the flue and combustion chamber of fire-tube boilers alone should be carried out after welding.

6.4.3 Boilers and pressure vessels that are welded using electroslag technique should have normalizing and tempering treatment after welding.

Section 5 Inspection

Inspection Methods

6.5.1 Inspection of welding quality of boilers and pressure vessels should be carried out according to the following methods:

(1) External quality inspection;

(2) Internal quality inspection;

(3) Mechanical property and macroscopic inspection;

(4) Sealing inspection and strength testing.

External Inspection

6.5.2 External welding inspection should be in accordance with the requirements specified in Section 1 of Chapter V.

Internal Inspection

(1) For internal welding quality inspection, radiographic observation or ultrasonic flaw detection may be used.

(2) Location of welds for flaw observation and detection should include all welding intersecting points of the drum, their per centage ratio in length and qualifying grades should meet the requirements specified in Table 6.5.3(2) below:

Table 6.5.3(2)

Classes of Boilers and Pressure Vessels		Longitudinal Weld		Circumferential Weld	
		Qualifying Grade	Per Centage Ratio	Qualifying Grade	Per Centage Ratio
I	$P \geq 32$	1	100%	1	50%
	$P > 6 \sim 32$		50%		25%
II		1	25%	2	15%
III		2	15%	2	10%

Note: (1) P in above figure is working pressure, kg/cm^2

(2) See Table 3.1.2 of Chapter III, Book II for the classes of boilers and pressure vessels.

(3) Per centage ratio of weld observation or flaw detection should be increased or reduced according to welding quality of the factories, welding techniques, materials and the degree of technical skill and experience, with the approval of the Ship Inspection Bureau.

(3) Standards of the determined welding quality by radiographic observation should be in accordance with Section 6.2.5 of this Book.

(4) If ultrasonic flaw detection is used for inspection, it should be in accordance with Section 6.2.6 of the Book.

(5) When welds failed to be qualified after inspection, repair of the defects by welding should be carried out and then be reinspected in accordance with Section 6.2.7 requirements of this Book.

Mechanical Properties and Macroscopic Inspection

6.5.4 Mechanical properties and macroscopic inspection of joints should be in accordance with the requirements described below:

(1) Selection of specimens: Welding specimens of Class I and II boilers and pressure vessels may be selected from the original weld or may be fabricated from the same materials, welding technique and heat treatment that are the same as the original weld.

(2) Number of specimens: Under the same conditions as to the same materials and welding technique, under the same heat treatment as one batch. The number of samples from the batch is: drum with a thickness of less than or equal to 18 mm, one piece of longitudinal weld; thickness greater than 18 mm, a piece each of longitudinal and circumferential weld. If the longitudinal and circumferential weld of the drum used the same welding technique, only one piece of longitudinal weld is needed; if the drum had only circumferential weld, one piece of circumferential weld should be fabricated. The length of the specimens should have sufficent additional volume for use in case of retesting.

(3) Factories that have stable welding quality, the number of specimens may be reduced, with the agreement of the Ship Inspection Bureau.

(4) Testing items and requirements should be according to Table 6.5.4(4) below:

Table 6.5.4(4)

Testing Items	Number of Specimens	Performance Requirements
Tensile test	1	Should not be lower than the lower value of the parent metal
Cold bending test	1	d = 2a * 160°; no fracture
Impact test	3	Should not be lower than the lower value of impact toughness of the parent metal
Macroscopic inspection	1	Should have no incomplete weld, slags and such similar defects

Note: (1)* If the parent metal is low alloy steel, testing should be carried out according to the bend center diameter d of the parent metal.

(2) Take the average value of the 3 specimens for impact toughness of the weld, but the lowest value of one of them should not be less than the required 80%.

(3) Welding of plates with a thickness under 12 mm may omit the impact test.

(4) If a certain test does not qualify, that testing item may be reinspected by selecting twice the number of specimens. If still not qualify, it should be analyzed and rewelded; the new weld should be subjected to heat treatment and then be retested.

(5) Work dimensions and testing methods of specimens for welding joint mechanical properties should be in accordance with requirements specified in Chapter II, Book VII.

Sealing Inspection and Strength Testing

6.5.5 Sealing inspection and strength testing of boilers and pressure vessels should be in accordance with the related requirements specified in Chapter III, Book II.

Chapter VII Welding of Major Machine Parts

Section 1 Welding of Rotor Shafts

7.1.1 This section applies to welding of rotor shafts of gas turbine engines, steam engines, exhaust turbine pressurizers.

Selection of Materials

7.1.2 In welding structures of rotor shafts, suitable welding materials should be selected. Welding rods, flux and other welding materials should be selected after welding tests, with their mechanical properties of the deposited metal not lower than the lower value of the mechanical properties of the parent metal.

Preparation Before Welding

7.1.3 Before welding rotor shafts, specimens should be fabricated according to determined and under the same condition and technique; flaw detection and metal phase inspection and mechanical property testing should be carried out. Work should be carried out only after testing and determined qualified. Specimens from products of batches, molds, and fixed pointed production, and under unchanged technique and materials may be selected at random, with the agreement of the Ship Inspection Bureau. Mechanical property testing includes tensile, longitudinal bending resistance, and impact testing Their value should not be less than design requirements.

7.1.4 Rotor shafts whould be subjected to pre-heating gradually before welding; during the welding process, thermal protection practice should be seriously watched. Temperature for pre-heating should be in accordance with the selected materials.

Heat Treatment and Inspection After Welding

7.1.5 Heat treatment should be carried out after the rotor shafts are welded; requirements for heat treatment should be in accord with the selected materials and welding methods.

7.1.6 Welds are subjected to flaw detection inspection in accordance with the requirements specified in Section 5.2.6 of this book.
Before refining, welds should be subjected to magnetic particle examination and other effective methods for surface inspection. Cracks must be completely eliminated and repaired, and heat treatment should be carried out to eliminate stress.

7.1.7 In welding rotor shafts, deformation must be severly controlled; if the volume of the deformation surpass the allowable value as designed, they should not be used.

7.1.8 Heat stability test for rotor shafts should be carried out in accordance with requirements specified in Section 5.4.3 of Book VII.

Section 2 Welding of Engine Base, Supports and Other Components

Applicable Range

7.2.1 This section applies to the welding of diesel engine seatings, engine casings, crankshafts, cylinders and turbines, and other components.

Selection of Materials

7.2.2 In welding structures of component members, steel plates, steel molds, forged and casting materials should meet the requirements specified in Book VII. Welding materials selected for used should be in accordance with the requirements specified in Chapter II of this Book.

General Rules

7.2.3 When it is first manufactured or using new welding technique, welding test should be specially carried out; its joint performance should be in accordance with the requirements of Section 3.5.4 of this Book.

7.2.4 Joints of major structures subjected to changing and impact load should be welded in the butt-bevele method, to insure full penetration of the thickness. In jointing two components with two different thickness, chanfering should be carried out to insure smooth transition, in accordance with requirements specified in Section 4.1.1 of this Book.

7.2.5 Before welding, welding edges should be cleaned; oxidized splinters, slags, oil pollution and other pollutents should not be allowed to exist.

7.2.6 Composite parts of structures with complex internal figuration, when they are welded together with the cast structures, should avoid sharp angle weld intersection or cross sectional sudden distortion.

Heat Treatment

7.2.7 Welds of jointed components should be subjected to surface inspection before heat treatment, according to the requirements specified in Chapter 5 of this Book. If problems in welds carried out according to Section 7.2.4 of this chapter arise, flaw detection using radiography or other reliable methods should be carried out.

7.2.8 Heat treatment should be carried out after the components are welded, to eliminate stress.

7.2.9 Components should generally not be welded again after heat treatment; if it must be welded again, its compensating welding technique should be specially considered.

Testing

7.2.10 All spaces subjected to pressure within components (such as turbine cylinder, welded pipe system of engines, cylinders, should be subjected to water pressure test, after their welds are inspected; testing pressure are:

When working pressure $P_s < 7\ kg/cm^2$:

$$P = P_s + 3.5 \quad kg/cm^2 ;$$

When working pressure $P_s \geq 7\ kg/cm^2$:

$$P = 1.5P_s \quad kg/cm^2 .$$

Normal sealing components should be subjected to sealing tests.

Section 3 Repairing Crankshaft Steel
Castings by Welding

General Rules

7.3.1 Defects of steel casting crankshaft may be repaired by welding, with the approval of the Ship Inspection Bureau.
In addition to the requirements of this Section 7.3.2, other defects may be repaired by welding when the conditions described below are satisfied:
(1) According to dimensions specified in the Rules, when dimensions of the various parts of the crank still have working volume.

(2) If the various parts of the crank no longer have any working volume, but effective technique can still be used to insure that the crank still has good quality.

7.3.2 Steel casting crankshaft may not be repaired by welding under situations described below:

(1) Defects resulted from low-quality materials or because of the wrong casting technique;

(2) Defective area of crank is too big, number of d fects too large;

(3) Needs storage welding to expand surface;

(4) Any defects appear in the important area of the crank.

Preparation before Repair by Welding

7.3.3 Before repair by welding, defects should be drill cleaned: channel formations should be rounded and smooth; non-destructive flaw detection should also be carried out.

7.3.4 Before welding, castings should be pre-heated; pre-heating temperature should not be lower than 200 degrees C; this temperature should be maintained untile the repair by welding is completed.

7.3.5 Welding rods selected for use should be certain of welding metallic property higher than the property of the base metal.

Heat Treatment After Repair by Welding

7.3.6 After repair by welding, castings should have heat treatment according to the size and location of the defects, to insure the castings with good quality.

Inspection

7.3.7 After repair by welding, the welded surface and the adjacent base metal should not have any defects.

7.3.8 Weld should be refined and smooth, with non-destructive flaw detection inspection, to certify good quality.

7.3.9 The manufacturing plant should include the defective condition, dimensions and location of the repaired castings, as well as the heat treatment technique and the results of the inspection of the repair by welding, together with diagrams, deliver to the Ship Inspection Bureau for examination.

Section 4 Welding of Shafting

Applicable Range

7.4.1 This section applies to the welding of thrust shafts, intermediate shafts, and bobbin shafts of the shafting of ships fabricated from carbon steel.

7.4.2 Materials of shafting should in accordance with the requirements of Section 1, Chapter VI, Book II. Welding materials should meet the requirements specified in Chapter II.

7.4.3 If the materials for shafting contain carbon exceeding 0.30%, specimens should be made according to same conditions and technique before welding; flaw detection inspection should also be carried out, as well as metal phase inspection and mechanical property testing. After testing and determined qualifying, welding can then be carried out.
Mechanical properties include tensile, bending resistance, and impact testing. Their value should not be less than the lower value of the requirements specified in Chapter VI, Book II.

Preparation Before Welding

7.4.4 Before welding, shafts should be pre-heated gradually; thermal protection should be seriously watched during the welding process. Temperature for pre-heating should be determined according to the materials selected for the shafts.

Heat Treatment After Welding

7.4.5 After welding, heat treatment should be carried out; heat treatment requirements are determined according to the carbon contents of the shaft and welding method.

Inspection

7.4.6 Flaw detection inspection of the weld should be carried out according to requirements specified in Section 5.2.6 of this book.

7.4.7 Welded surface of shaft should have mechanical refining, to make the surface smooth and shining.
After rough working at the welded area, magnetic particle examination for flaws and other effective inspection methods should be carried out before refining operation. Fractures should be completely eliminated and repaired; heat treatment is conducted to eliminate stress.

Chapter VIII Welding of Pipe Systems

Section 1 General Rules

8.1.1 Welding rods, strips, and flux for use in welding pipe systems and fittings should be in accordance with the requirements specified in Chapter II, "Welding Materials".

8.1.2 In welding important pipe system and parts of cast iron or nonferrous metals, the selected welding rods or deposited metals should be approved by the Ship Inspection Bureau.

8.1.3 Before welding, the oxidized splinters, moisture, oil pollution and other pollutants of the weld edges should be removed. Weld gap and grooves should meet design requirements.

8.1.4 Welds are not permitted to be placed on pipe bends and expanded, compensated areas; welds should be placed in the area where minimum bending strength or changing load occur.

Section 2 Types of Pipe Joints

8.2.1 Welded flange for pipes should be in accordance with official designated diameters for pipes; working pressure and working temperature should be selected according to the types required by national standards.

8.2.2 When branch pipes are welded to the main pipes, if the diameters of the branch pipes are smaller than the main pipes, they should be welded in accordance with Fig. 8.2.2 below; if the diameters of the branch pipes are equal or closer to the diameters of the main pipes, they should be welded in accordance with Fig. 8.2.2 below. The above mentioned welding may also use other reliable methods.

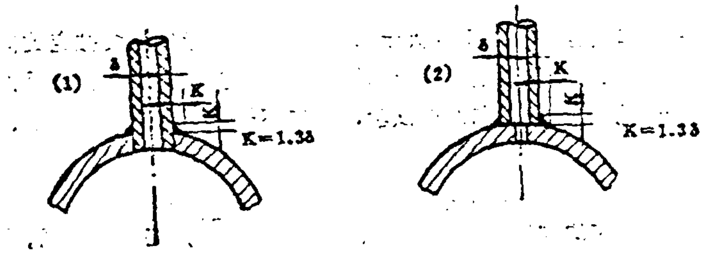
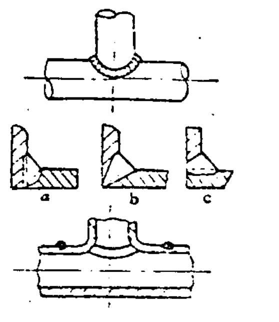
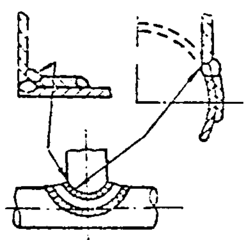


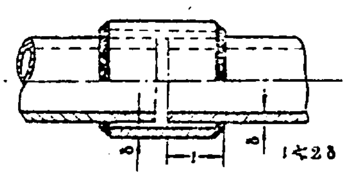
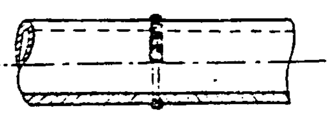
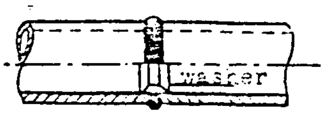
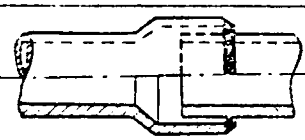
Fig. 8.2.2

Table 8.2.2

Type	Pipe Joints	Working Pressure (kg/cm²)	Branch Pipe Diameters (mm)
1	(1) 	Under 20	Under 150
	(2)	20~30	Under 100
2		10~30	Under 200
		30~40	Under 150

8.2.3 Butt welding joints of pipes may be selected according to Table 8.2.3 below:

Table 8.2.3

Type	Pipe Joints	Working Temper-	Pressure (kg/cm²)	Pipe (mm)	Remarks
1		Under 100	Under 10	Under 50	
		Greater than 100.	Under 5		
2		Under 100	Under 20	Under 300	
		Greater than 100		Under 50	
3		No Limit			According to the purpose and requirements of the piping system, a stationary steel washer or a removable copper washer may be used.
4		Only permit for [illegible] copper or copper alloy, with applicable pressure and temperature range in accordance with the requirements specified in Sect. 1, Chapter [illegible]			

Section 3 Heat Treatment

8.3.1 After welding important pipes and flanges of high temperature and high pressure, if they are made of heat-resistent alloy steel or carbon steel containing more than 0.24% carbon, heat treatment should be carried out to improve the weld and the metallic composition of the heat affected area.

8.3.2 When heat treatment is carried out in accordance with Section 8.3.1, the entire section or part of the welded joint should be subjected to heat treatment.

Section 4 Inspection of Welding Quality

8.4.1 After the pipes are welded, the inside slag should be removed, and the surface quality of the weld should be inspected; welded surfaces should not have any cracks, swelling outgrowths, air holes, and unfilled arc pits or dents; welded edges should not have any deep gnaws or bites. If any of the above mentioned defects exist, repairs should then be carried out.

8.4.2 After steam pipes having a working pressure greater than 16 kg/cm^2 and having a temperature greater than 350 degrees C are welded, their welding quality should be inspected, using x-ray or gamma ray or other reliable methods and they should meet the requirements of Grade 1 standards specified in Section 2 of Chapter 5.

Chapter IX Riveting

Section 1 General Rules

9.1.1 This chapter applies only to the partial riveted structures of hull weld as specified in the present Rules for the Construction of Sea-going Steel Ships.

9.1.2 Riveting materials should meet the requirements specified in Section 4, Chapter 3, Book VII.

9.1.3 Standard shipbuilding rivets are to be used in all hull riveted structures .

9.1.4 Under general conditions, riveting is to be performed after completion of welding.
If riveting is to be carried out at the same time of welding, riveting should be performed at the area about 300 mm from the joint, after completion of welding.

9.1.5 Joint surfaces of riveting should be cleaned and smooth; joints should be tight, and should not have any contaminating substances and should not be grooved or uneven.

9.1.6 Rivets should match with rivet holes. Under particular conditions, unfair rivet holes may be remedied by reaming the holes or by welding up the holes, when they do not affect the joint strength.

9.1.7 Oiltight rivet joints generally should not be installed with gaskets. When it is difficult to insure oiltight requirements during riveting, gaskets that are insoluble in oil are permitted for installation.

9.1.8 Holes for the countersunk rivet points are to be punched.

9.1.9 After riveting is completed, edges of the jointed parts should be caulked. The distance between the center and the edge of the rivet holes of the jointed parts should not be less than 1.5 times the diameter of the rivet after caulking.

BOOK VII MATERIALS

Chapter I General Provisions

Section 1 General Rules

1.1.1 Quality and testing of important materials and manufactured products of ship hulls, boilers, pressure vessels, and machinery of sea-going vessels must be in accordance with the provisions specified in this Book; complete and certified documentation must be prepared for them. If there are some that do not meet certain requirements, they must be approved by the Ship Inspection Bureau.

1.1.2 Chemical composition, mechanical properties and testing methods for those materials and manufactured products of ship hulls, boilers, pressure vessels, and machinery of sea-going vessels that have not been included in this Book may be tested and accepted in accordance with the national standards with the agreement of the Ship Inspection Bureau.

1.1.3 New products and materials must be certified by the departments concerned, and must be approved by the Ship Inspection Bureau.

1.1.4 Ship materials and manufactured products that had been inspected by the Ship Inspection Bureau must be stamped with the certification seal of the Ship Inspection Bureau. The seal sample should be the same as Figure 1.1.4.

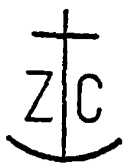


Figure 1.1.4

Section 2 Inspection of Ship Hull Materials

Products Inspection

1.2.1 Products inspection refers to the inspection of shipbuilding materials and manufactured products conducted by the manufacturing plants in accordance

with the present Rules and merchandise ordering conditions. After inspection, manufacturing plants must issue the quality certificates of the shipbuilding materials and manufactured products.

If the Ship Inspection Bureau considers it necessary, inspectors may be dispatched to the manufacturing plants to participate in the inspection. After inspection and certification, the verification seal of the Ship Inspection Bureau may also be struck on the manufactured products.

Reexamination and Inspection

1.2.2 Reexamination and inspection refer to the spot checking or supplementary testing of ship hull materials or manufactured products conducted by the shipyards (or factories producing the ship machinery) according to the present Rules.

Shipyards generally need not carry out any reexamination or inspection of shipbuilding materials and products that had been inspected and certified with quality certificates in order, if no special condition exists. If the quality of the materials or products are unknown, or testing items included in the quality certificate do not meet the requirements specified in the present Rules, supplementary testing must be carried out.

Section 3 Treatment of Defects

1.3.1 During the work process or the installation of the shipbuilding materials or products, if low quality of the products is discovered, whether or not the materials or products are supplied with a quality certificate or had been reexamined or inspected and certified, they are not permitted for use. However, a reexamination of the same batch of materials or products may be conducted.

1.3.2 If partial defects are discovered in the original materials or products, under the condition that it would not affect the product quality, repair by welding according to specific conditions may be carried out. Repair by welding of

important materials or products may be carried out with the agreement of the Ship Inspection Bureau.

Section 4 Heat Treatment

1.4.1 Important casting and forged parts must be subject to heat treatment; heat treatment process is formulated by the manufacturing plants.

Chapter II Testing Methods and Specimens

Section 1 General Rules

2.1.1 The present Chapter describes the testing requirements of general properties of shipbuilding materials. Special testings and specific technical standards for materials are specified in various chapters and sections of the present Rules.

2.1.2 Casting specimens fundamentally should be poured out among the same castings; if special requirements exist, casting specimens may be poured out alone from the metals of the same batch of the products of the same foundry.

2.1.3 Specimens of parts that must be subject to heat treatment should be cut and selected from the parts after heat treatment. Specimens that were selected alone should be subject to heat treatment together with the other parts.

2.1.4 The cutting and selection of specimens should be carried out by the cold working method. If the specimens are cut and selected by flamming or electric arc method, their cutting line distance from the edge of the specimens must be at least or equal to the thickness of the materials, but not less than 10 mm.

2.1.5 During the process of mechanical testing of specimens, if the unsatisfactory tested items occurred because of accidental defects, new specimens may be cut and selected from the same materials of the specimens.

If the unsatisfactory test was not caused by accidental defects in the specimens, the unsatisfactory items should be retested, selecting twice the number of

specimens from the same batch of materials. After retesting, even if only one specimen failed to qualify, that batch of materials or that particular item or part are not permitted for use. However, the unsatisfactory item of that batch of materials may be retested one by one according to specific conditions; those that then meet satisfactory requirements may be permitted for use. The manufacturing plants may also carry out a new testing of the batches of materials of all satisfactory items after heat treatment in accordance with the requirements of Section 2.1.3; those that then meet the satisfactory requirements are permitted for use.

Section 2 Tension Tests

2.2.1 Tensile strength σ_b, yield point σ_s, elongation ratio δ, and cross-sectional area reduction ratio ψ and other mechanical properties of shipbuilding materials should be determined by the tension test.

Tension Specimens

2.2.2 Forms and dimensions of tension specimens

(1) Standard specimens and proportional specimens (different cross-sectional shapes) used for the tension test should meet the requirements specified in Table 2.2.2 (1).

Fig. 2.2.2 (1)

Specimens		Gauge length l_0 (mm)	Cross-section area F_0 (mm²)	Round specimen diameter d_0 (mm)	Symbols of specimen multiple number
Standard	long	200	314	20	δ_{10}
	short	100			δ_5
Proportional	long	$113\sqrt{F_0}$	as desired	as desired	δ_{10}
	short	$5.65\sqrt{F_0}$			δ_5

Note: Other proportional specimens using the gauge length and diameter or cross-sectional area [such as castings and forgings using specimens with gauge length 2.5 times the diameter ($\delta_{2.5}$)] may be permitted, but should be pointed out on the certificate.

(2) Dimensions, allowable tolerances, and smoothness of surface working of round specimens should meet the requirements specified in Figure 2.2.2 (2) and Table 2.2.2 (2).

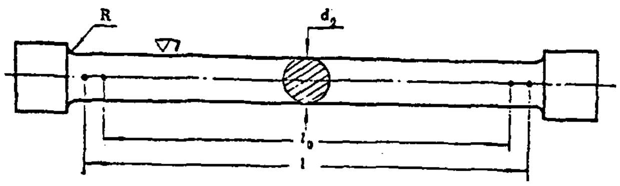


Figure 2.2.2(2)

In the figure:

Gauge length $l_0 = \begin{cases} 10d_0\text{(长试样}\delta_{10}\text{)}, \text{ mm}; & \text{long specimens} \\ 5d_0\text{(短试样}\delta_5\text{)}, \text{ mm}; & \text{short specimens} \end{cases}$

$l = l_0 + d_0$, mm;

$R = 3\text{--}5$, mm;

d_0 = specimen diameter

Specimen diameter d_0 (mm)	Allowable tolerances (mm) of gauge section of specimen		Allowable differential value of max. and min. diameter within the gauge length of specimens (mm)
	Diameter d_0	Gauge length l_0	
<10	±0.1	±0.1	0.02
⩾10	±0.2	±0.1	0.05

Note: Allowable tolerances of casting specimen diameter may be double.

(3) Dimensions and machining smoothness of plate-shape specimens should meet the requirements specified in Figure 2.2.2 (3) (a) or (b).

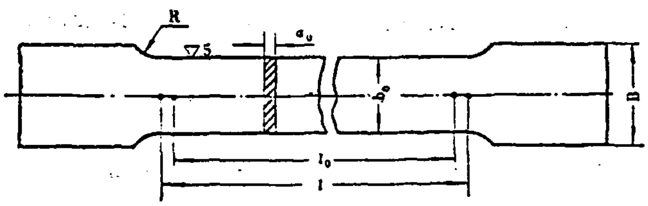


Figure 2.2.2(3)(a)

In Figure: a_0 = Steel plate thickness

$b_0 = 30$mm;

$B = 40$mm;

$l_0 = \begin{cases} 11.3\sqrt{a_0 b_0} \text{ (long specimen) mm;} \\ 5.65\sqrt{a_0 b_0} \text{ (short specimen) mm;} \end{cases}$

$l = l_0 + 15$mm;

$R = 3\sim 5$ mm.

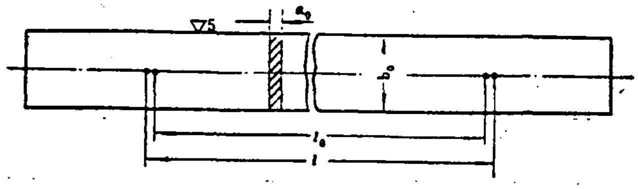


Figure 2.2.2(3)(b)

In Figure $a_0 = 4 \sim 25mm$,

$b_0 = 30mm$,

$l_0 = \begin{cases} 11.3\sqrt{a_0 b_0} & \text{(long specimen) mm;} \\ 5.65\sqrt{a_0 b_0} & \text{(short specimen) mm;} \end{cases}$

$l = l_0 + 15mm$.

Allowable tolerances of specimen dimensions shown in the two figures above:

Specimen width b_0 .... $\pm 0.5mm$,

Specimen length l_0 .... $\pm 0.1mm$,

Max. & min. width differential value within gauge length.....0.1mm.

A rolling surface should be kept in plates with a thickness greater than 25mm, then plane down to 25 mm; and a round specimen of approximately the same thickness may also be made.

(4) An entire sectional surface test should be carried out for the hot rolled sectional sticks with a diameter less than or equal to 25 mm; specimens should maintain the original rolling surace; for those with a diameter exceeding 25 mm, their specimen dimensions should be machined to meet the requirements specified in Table 2.2.2 (2) and Figure 2.2.2 (2).

(5) For tin bronze and brass, specimen dimensions should be:

$$d_0 = 10mm, \quad l_0 = 50mm.$$

For bronze containing no tin, specimen dimensions should be:

$$d_0 = 15mm, \quad l_0 = 150mm.$$

For aluminium alloys and magnesium alloys, specimen dimensions should be:

$$d_0 = 12mm, \quad l_0 = 60mm.$$

(6) For flake-graphite cast iron, specimen dimensions should be:

$$d_0 = 10mm, \quad l_0 = 50mm.$$

Dimensions may also be:

$$d_0 > 10mm, \quad l_0 = 5d_0.$$

(7) For testing of grey cast iron, see Section 8 of this Chapter.

Tension Tests

2.2.3 Tension tests should be carried out at the ambient temperature (20°C ± 10°C). During testing, the speed of shifting the machine's two grips under authorized load should be as follows:

(1) Before the yield point (σ_s) or yield strength ($\sigma_{0.2}$) is reached, it should not be greater than 8%/second of the original gauge lenth.

(2) After the yield point is reached, it should not be greater than 40%/second of the original gauge length.

Estimation of Tension Properties

2.2.4

(1) The yield point is defined as the point determined during the elongation process corresponding to the first drop of the index showing the maximum and minimum load applied to, and, except that of the original cross-sectional area's yielded stress (kg/mm^2), its accuracy should be within 0.5 kg/mm^2.

(2) Tension resistance strength is defined as the specimen's maximum load before tension fracture, except that of the original cross-sectional area's yielded stress (kg/mm^2), its accuracy should be within 0.5 kg/mm^2.

(3) Elongation ratio is defined as the percentage between the increased gauge length and the original gauge lenth after tension fracture of the specimen, its accuracy should be within 0.5%.

(4) The reduction ratio of the fracture surface is defined as the percentage between the reduction am unt of the fractured cross-sectional area and the original cross-sectional area after tension fracture of the specimen, its accuracy should be within 0.5%.

Supplementary Tests

2.2.5 If the results on an original tension testing specimen do not reach twice the diameter or width, starting from the fracture point, and its elongation ratio does not meet the stated or required value, such test is deemed ineffective and supplementary tests must be carried out. If tension tests form double shrinkage bottlenecks, a new specimen should be selected. A sup lementary test of another specimen must be selected from the same heat or test lot of materials.

Section 3 Impact Tests

2.3.1 The objective of impact test is to determine the impact energy loss of the metalic materials during fracture under power loading condition at ambient and low temperatures.

Impact test is generally shown with the impact power A_k**(kg-m)** or impact value α_k**(kg-m/cm²)**.

Impact Testing Specimens

2.3.2 Types and dimensions of impact testing specimens

(1) Dimensions, allowable tolerances and proposed machining smoothness of U-notch type of impact specimens should be in accordance with the requirements specified in Figure 2.3.2 (1).

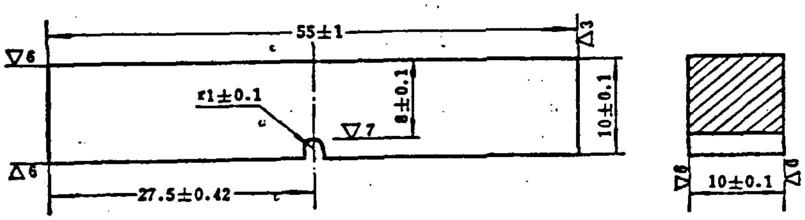


Figure 2.3.2(1)

(2) Dimensions, allowable tolerances and proposed machining smoothness of V-notch type of impact specimens should meet the requirements specified in Figure 2.3.2 (2).

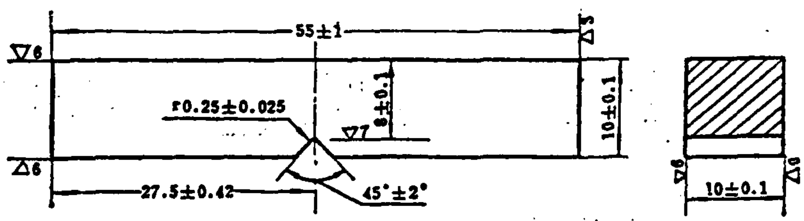


Figure 2.3.2(2)

2.3.3 Selection and Machining of Impact Test Specimens

(1) Positions, the number of selections, and orientation (direction of longitudinal, horizontal and firing off) of impact testing specimens from materials are described

in various sections and chapters below. During the selction process of the specimens it should be assured that the metals should not be affected by the cold treatment or heat to cause a change in their properties.

(2) Specimens must be machined at the four surfaces. However, in accord with certain related technical conditions, the surface having the notch perpendicular to one of the original surfaces, or with materials having a thickness of 10 mm, two surfaces without machining are allowed.

(3) The notch of the specimen should be perpendicular to one of the original rolled surfaces, in accordance with the requirements specified in Figure 2.3.3 (3).

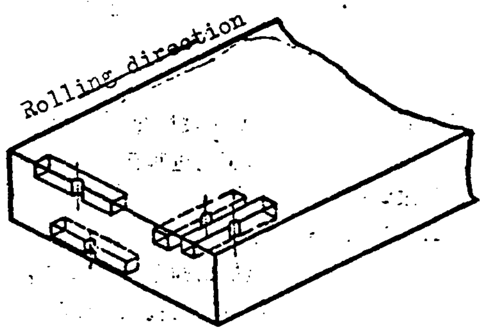


Figure 2.3.3 (3)

Impact Tests

2.3.4 The impact tests should be carried out on a pendulum-type impact testing machine, with the specimen freely placed on two racks. The maximum energy of the testing machine generally should not be greater than 30 kg-m. Velocity of the machine pendulum at the moment of striking the specimen should be within 4--7 m/sec. The machine pointer (or gauge) should assure the reading accuracy of the impact power not less than 0.5% of the energy. Impact testing machine support and the major dimensions of the pendulum should be in accordance with the requirements specified in Figure 2.3.4.

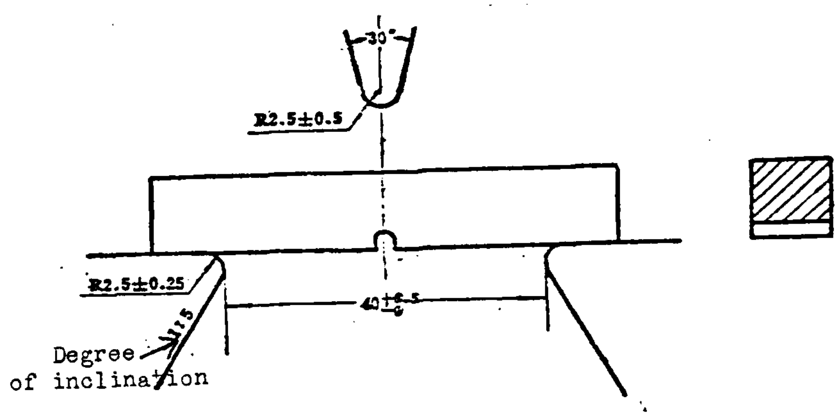


Figure 2.3.4

2.3.5 Impact test may be carried out under room temperature, from $20^\circ C \pm 5^\circ C$ or at low temperatures of $0^\circ C$, $-10^\circ C$, $-20^\circ C$, and $-40^\circ C$.

During low-temperature testing, specimens should be subject to cold treatment to reach a low temperature of $-60^\circ C$, using ice and should not use unfreezable liquid or other mixtures as the colding agents. Ice should be poured in a stirring fashion so that the temperature would be uniform. After the colding agent is poured into the container and after reaching the required degree for a time of not less than 5 minutes, the specimens may then be put in. The specimens should remain in the container for a period of not less than 15 minutes, after the temperature once again reaches the required degrees. The specimens should then be quickly taken out for the impact test, within the time limit of 2 to 5 seconds. The suggested cold treatment temperature should under $3^\circ C$ to $4^\circ C$.

During the impact test, the gap between the pendulum striking point with the notch of the specimen should not exceed 0.5 mm. Accuracy of the reading figure of the impact power should be within 0.1 kg-m.

Section 4 Deformation Time Effect Tests

2.4.1 The objective of the deformation time effect tests for steels is to determine, after plastic deformation under cold treatment, the changes in mechanic properties caused by the internal fusion precipitation process under ambient or high temperatures for an extended time.

Time Effect Specimens

2.4.2 Specimens

Specimens are selected for deformation time effect testing from one sample blank with a length of 300-400 mm and a width of 30 mm from the steel plates and steel molds. The sample blank should be elongated to obtain a 10% permanent deformation, allowing a tolorance of 0.5%. Afterward, select a specimen as indicated by Figure 2.4.2 from the gauge length of the sample blank which forms a blank sample measuring 10.5 x 55 mm after machining, with one side maintaining the rolling surface. At this time make it into an impact specimen according to the dimensions and finishing smoothness specified in Section 2.3.2 after machining.

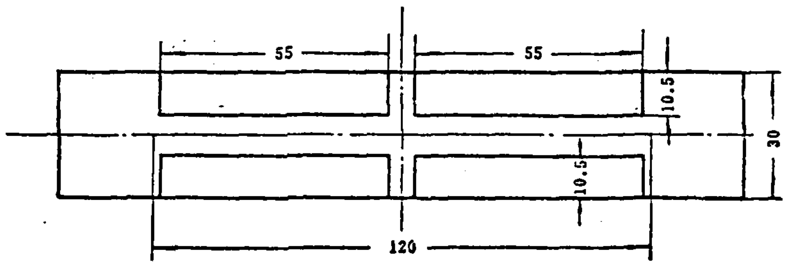


Figure 2.4.2 Front view of this figure is the rolling surface

Time Effect Tests

2.4.3 The manufactured specimen is heat treated homogeneously under temperatures of $250^\circ C \pm 10^\circ C$ for one hour (artificial aging), then cool it in the air. Heat

treatment of the specimens may also be carried out before polishing.

Impact test for impact specimens after the time effect testing should be carried out by the pendulum type impact testing machine within a specific energy range, under room temperature of 20° C±5° C.

Section 5 Bend Tests

2.5.1 The objective of bend test is to examine the bending plastic properies of steels yielded according to required bending levels after cold and heat treatment or after treatments similar to quenching temperatures and other conditions and to detect defects.

Bend Test Specimens

2.5.2 Dimensions of Specimens

Bend test specimens are divided into several types as described below, according to their materials, types, and technical requirements:

(1) Ordinary steel plates, steel molds, and flat steels with a width exceeding 100 mm are divided into standard and wide specimens, according to their various technical requirements:

① Standard specimens: Thickness t=thickness of the original materials (maintaining original rolling surface);

Width $b = 2\ t \pm 2$ mm, but not less than 10 mm;

Length $L = 5\ t + 150$ mm.

② Wide specimens: Thickness t thickness of the original materials (maintaining original rolling surface);

Width $b = 5\ t \pm 2$m;

Length $L = 5\ t + 150$ mm

The degree of smoothness after polishing of the side surface of of the side surface the plate should not be less than, its corner may be made into an arc with a radius not to mm exceed 2 mm.

(2) The cross section of specimens of steel materials with square sections having a width less than 100 mm or circular sections should be equal to the cross section of the original materials. The length of specimens, L, should be equal to 5 times the thickness or the diameter, plus 150 mm.

(3) Dimensions of cold bending specimens of forged steel parts should be: 10 x 20 x 160, with each side measuruing in mm; each side being small round corner with a radius of 1 mm.

(4) Dimensions of cold bending specimens of casted steel parts should be: sections of 20 x 25, with each side measuring in mm; length not less than 200mm; corner sides made into round corners with a radius of 2 mm; diameter of the bend center d = 50 mm.

When problems arise in obtaining specimens, sections of 10 x 12.5 may also be used as specimens, with each side measuring in mm; diameter of the bend center d = 25 mm.

Bend Tests

2.5.3 Bend tests are divided into the following types, according to their characteristics:

(1) Cold bending: Bend tests of specimens are carried out under room temperature.

(2) Hot bending: Bend test of specimens are carried out with the testing machine, under a temperature specified by a certain technical requirement; the specimens are to be heated homogeneously before bending occurs.

(3) Tempering bend tests: Bend test of specimens are carried out after the specimens are completely cool with water with temperature of 20° to 30° C; specimens

should be heat treated to a temperature of 650° to 700° C before tempering bend tests are carried out.

(4) Non-quenching hardness bend tests: Bend tests are carried out after cooling in water; specimens are to be heated at the quenching temperature before carrying out the tests.

2.5.4 In conducting bend tests, specimens are placed on the compressor (or special testing machine) or other equipment; bending operation is carried out according to specified technical requirements with respect to the diameter of bend center, d, and to bending angle as indicated in Figure 2.5.4.
After bend tests, if examination of specimens reveals no cracks, fractures, pores and other defects present inside and outside of the bending area, the test is deemed satisfactory.

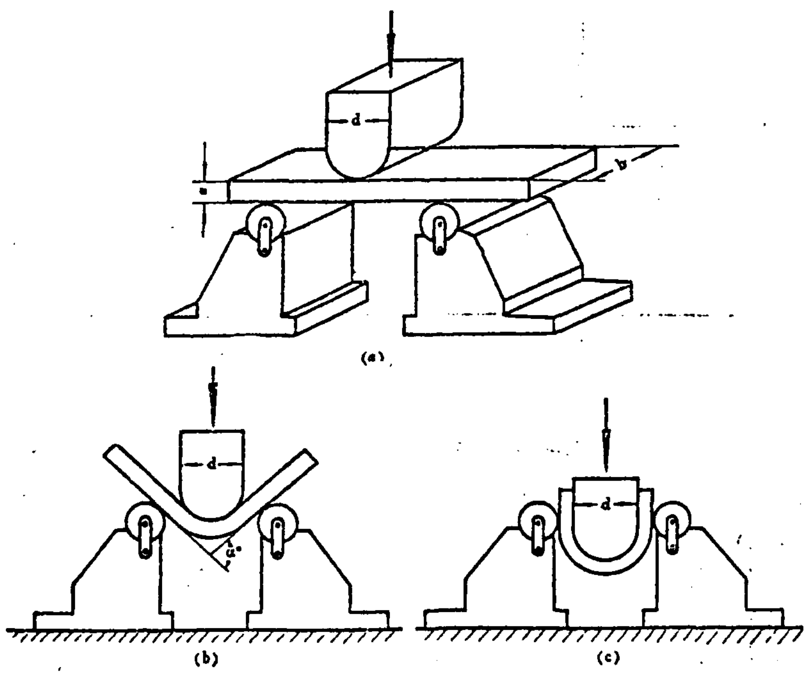


Figure 2.5.4

Section 6 Top Upsetting Tests

2.6.1 The objective of top upsetting test is to examine and to determine the plastic transformation properties of rolled steels, rivets, bolts, and other steel materials subject to top upsetting under cold and hot environments.

Top Upsetting Test Specimens

2.6.2 Specimens may be selected from rolled steels, rivets, bolts, and other steel materials that are apparently satisfactory after an examination; their dimensions should be: cross sections should be the same as the sections of the original materials (the same as maintaining the original rolling or drawing surface), with heights 2 times the diameter; ends should be vertical with the axis of the specimens.

2.6.3. Top Upsetting Tests

Top upsetting tests should be carried out with a compressor or forging machine, at room temperature or at a temperature for homogeneous heat treatment that satisfies a certain technical requirement. Specimens with diameter less than 115 mm may be forged with hammers during top upsetting operation; however, specimens should not have any signs of twisted or uneven forging.

2.6.4. Specimens during top upsetting operation should reach a height of a certain specified technical requirement as shown in Figure 2.6.4, they should not have cracks, fractures or other defects.

In the Figure, h_1 is the height after top upsetting operation; h is the height before the specimen goes through the top upsetting operation.

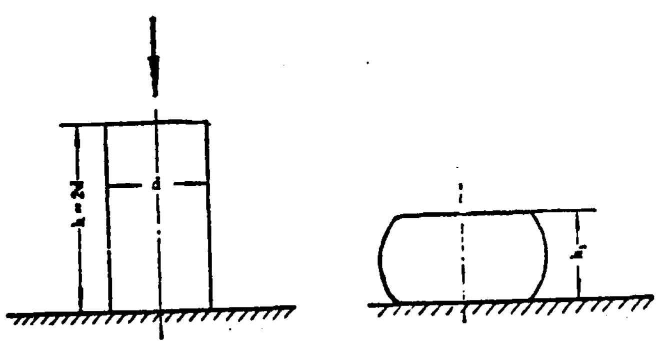


Figure 2.6.4

Section 7 Brinell Hardness Tests

2.7.1 The Brinell hardness test is carried out to calculate the Brinell hardness value, using steel balls with a definite diameter according to the required load compressed onto the surface of the testing metals (as indicated in Figure 2.7.1 (a)); after subject to a load for the required time and then unload (as shown in Fig. 2.7.1 (b)), the diameter of the compressed scar of the specimen surface can be calculated. The hardness value is shown by the symbol HB△△.

(1) The Determining method's applicable range for Brinell hardness of metals and other alloys as specified in this section is HB=8～450.

(2) The Brinell hardness value is shown by the average pressure (kg/mm^2) applied to the scared surface area of the steel ball of the tested specimens; the formulas below may be used for calculating the hardness value:

$$HB = \frac{2P}{\pi D \cdot (D - \sqrt{D^2 - d^2})}$$

In the formula:

P----load applied to specimen surface at which the steel ball pressure goes through, kg;

D----diameter of steel ball, mm;

d----diameter of pressure scar, mm.

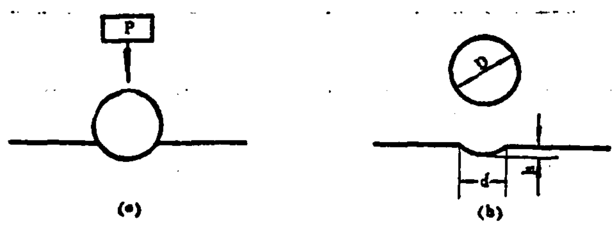


Figure 2.7.1

Hardness Specimens

2.7.2 Specimens

(1) Thickness of the specimens should not be less than 10 times the depth of the pressure scar. If there are other requirements specified by technical contions, the thickness may be 8 times. The depth of pressure scar may be

obtained from the following formula:

$$h = \frac{P}{\pi DHB}$$

In the formula: P, D and HB are the same as 2.7.1 (2) above.

(2) The length and width of specimens should not be less than two times the diameter of the steel ball.

(3) The surface area of specimens should be polished smoothly, so that the pressure scar may leave sufficient clearity around the edges to insure the accuracy in calculating the diameter of the pressure scar.

Hardness Testing Machine

2.7.3 The Brinell hardness testing machine should be able to carry the additional load evenly and under a stable condition; and should also be able to maintain the additional load without change in the required time; the difference in inclination should not exceed 0.2/100 when action is vertically applied to the surface; allowable error of the load should not exceed ±1%.

The steel ball for hardness testing should be made of quenching hard steel with its hardness not less than Vickers hardness value H_v850. The smoothness of the steel ball surface should not be less that $\nabla 12$; any surface defects should be observed under the microscope with a magnitude of 5.

The diameter and allowable tolorance of the stall ball should be in accordance with Table 2.7.3 below:

Table 2.7.3

Diameter of Steel Ball (mm)	Maximum allowable tolorance (mm)
2.5	±0.005
5.0	±0.005
10.0	±0.010

Hardness Tests

2.7.4 The Brinell hardness test should be carried out at temperatures of $20^\circ C \pm 10^\circ C$. During testing, the diameter, the size of the load, and the load maintaining time of the steel ball should be selected according to the predicted hardness and thickness of the specimens as shown in Table 2.7.4 below:
During testing, the distance between the pressure scar central distance and the edges should not be less than 2.5 times the diameter of the pressure scar; adjacent scar central distance should not be less than 4 times the diameter of the pressure scar.

Table 2.7.4

Type of Metal	Range of Brinell hardness HB	Thickness of specimens (mm)	Relationship between load P and diameter D of steel ball	Steel Ball Diameter (mm)	Load P (kg)	Loan maintaining time (sec.)
Ferrous Metal	140~450	6~3	$P = 30D^2$	10.0	3000	10
		4~2		5.0	250	
		<2		2.5	187.5	
	<140	>6	$P = 10D^2$	10.0	1000	10
		6~3		5.0	250	
		<3		2.5	62.5	
Nonferrous metal	>130	6~3	$P = 30D^2$	10.0	3000	30
		4~2		5.0	750	
		<2		2.5	187.5	
	36~130	9~3	$P = 10D^2$	10.0	1000	30
		6~3		5.0	250	
		<3		2.5	62.5	
	8~35	>6	$P = 2.5D^2$	10.0	250	60
		6~3		5.0	62.5	
		<3		2.5	15.6	

2.7.5 The size of the diameter d of the pressure scar should be within the range below, after the test had been conducted:

$$0.25D < d < 0.6D$$

In the formula: D----Diamter of the steel ball, mm.

If the above mentioned conditions are not met, then the tests are not effective.

When hardness test using steel balls with a diameter of 10 mm or 5 mm, the calculation accuracy of the pressure scar diameter should be within 0.02 mm; if 2.5 mm steel balls are used, the accuracy should reach 0.01 mm.

2.7.6 The hardness value of metals may be obtained according to the equation indicated in 2.7.1, according to the diameter of the pressure scar, the size of the load, and the diameter of the steel ball, such as follows:

HB > 100, changing into an integral number;

HB=10~100, select the first unit of the decimal figures

HB<10, select the second unit of the decimal figures

Section 8 Testing of Tensile Strength and Bending Resistance of Gray Iron Castings

2.8.1 Tensile tests for gray iron castings are carried out to determine the tensile strength of gray iron castings under ambient temperatures, the value σ, and to observe fracture conditions:

$$\sigma_b = \frac{P_b}{F} \quad kg/mm^2$$

In the formula: P_b----maximum tensile load, kg;

F----minium cutting area of horizontal parts of the specimens before the test is conducted, mm^2.

Tension Specimens

2.8.2 Diagram, polishing smoothness, and dimensions of tension specimens should be in accordance with the requirements specified in Figure 2.8.2 and Table 2.8.2.

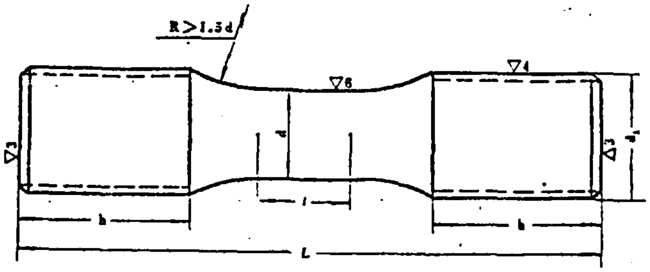


Figure 2.8.2

Table 2.8.2

Diameter of Blank (mm)	Specimen diameter d (mm)	Length of horizontal l (mm)	Length of ends h (mm)	Screw-thread diameter d_1	Total length L (mm)
13	8 ± 0.05	8	16	M12	54~56
20	13 ± 0.05	13	24	M18	82~87
30	20 ± 0.1	20	36	M28	126~132
45	30 ± 0.2	30	50	M42	174~180

Tension Tests

2.8.3 Tension test may be carried out with any tension testing machines; however, the fixtures of the testing machine must insure their ability to maintain a center of symmetry; the loading accuracy of the testing machine must be within 1% of its indicated value.

Bend Resistance Tests

2.8.4 Bend resistance test of gray iron castings is to determine the degree of bend resistance σ_w under ambient temperatures and under static conditions:

$$\sigma_w = K \cdot P \quad kg/mm^2$$

In the formula: P----load of specimen during fracture, kg;

K----constant, $K = \frac{8l}{\pi d^3}$;

l----central distance of bearing roller, mm

d----diameter of specimen, mm.

Bend Resistance Specimens

2.8.5

(1) Bend resistance specimens should be selected by the baked, vertical sintering method.

(2) Bend resistance specimens normally use blank specimens; if special requirements exist, machining specimens may be used.

(3) Allowable tolorances of the shortest length and diameter of specimens should be in accordance with the requirements specified in Table 2.8.5 (3) below:

Table 2.8.5(3)

Diameter of specimens d (mm)	Diameter allowable tolorances (mm)		Shortest length L (mm)
	Blank specimens	Machining specimens	
13	±1.0	±0.1	160
20	±1.0	±0.2	240
30	±1.0	±0.2	340
45	±1.4	±0.2	500

(4) The surface of the blank specimens should be smooth, straight, and should not have air holes or other defects. The smoothness of the machining specimens should not be less than $\nabla 5$, its surface should not have any cutting scars.

(5) The maximum and minimum diameter difference of the same surface of the blank specimens should not be greater than 3% of the value of the minimum diameter; otherwide their bend resistance strength should be calculated according to the real ellipse sectional constant. For this type of bend resistance test of specimens, it should be conducted according to the specimen's minimum diameter's direction for loading.

Ellipse sectional and revised constant K should be calculated according to the equation below:

$$K = \frac{ab^2}{d^3}$$

In the equation: a----diameter of specimen at the point where fracture occurs, mm;

b----diameter of specimen at the point where fracture occurs at the same direction, mm;

d----nominal diameter of specimen, mm.

Bend Resistance Tests

2.8.6 Installation for bend resistance test should be according to Figure 2.8.6 below:

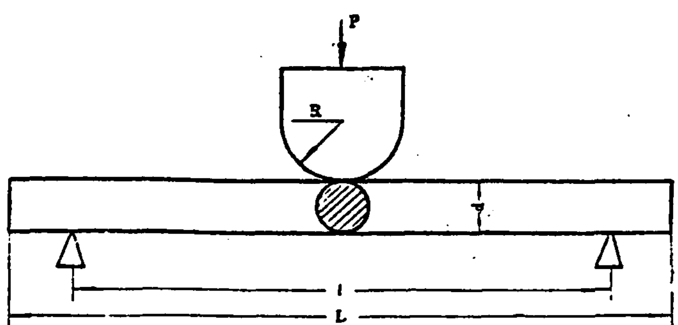


Figure 2.8.6

(1) Bend resistance testing machine should be able to regulate its speed, and able to maintain its loading error within 1%.

(2) The radius of bearing roller and the size of the radius of the reciprocal head R of the testing machine are specified as follows:

When diameter of specimen is $d \leqslant 20$mm, $R \geqslant 15$mm;
When diameter of specimen is $d \geqslant 30$mm, $R = (15 \sim 25)$mm.

2.8.7 Requirements of bend resistance tests

(1) Testing requirements and reading accuracy should be in accordance with Table 2.8.7 below:

Table 2.8.7

Diameter of specimens d (mm)	Central distance of bearing roller l (mm)	Reading accuracy		Initial load (kg)
		Diameter (mm)	Load (kg)	
13	130	0.1	5	6~10
20	200	0.1	10	20~30
30	300	0.1	20	30~50
45	450	0.2	50	30~50

(2) Specimens placed at the central portion of the bearing roller should maintain balance. The longitudinal axis of the roller should be vertical with the center line of the specimens.

(3) The time t starting from the initial loading to the fracture point of each specimen should be in accordance with the size of the diameter d of the specimens, as indicated below:

$d \leqslant 20$mm, $t > 20$ second;
$d = 30$mm, $t > 30$ second;
$d = 45$mm, $t > 45$ second.

Section 9 Analysis and Flaw Detection

2.9.1 Analysis is the process through which chemical, low-multiple, microscopic, and nondamaging flaw detection method to determine the elements of metals or the defects of their composition.

Chemical Analysis

2.9.2 Chemical analysis is the use of suitable methods to determine the chemical composition of the materials. Testing departments should insure the reliability and accuracy of their analyses.

Low-multiple Examination

2.9.3 Low-multiple examination uses the naked eye or low multiple (under 5 times) magnifying glasses to examine the defects (shrinking holes, air holes, cracks, white spots, etc.) and to determine the heterogeneity of physics and chemistry.

(1) Vulcanizing seal examination. is the process of examining sulfuric segregation.

(2) Acid absorption method is the process used to examine the heterogeneity of carbon steel crystals, cracks, shrinking holes, and other defects. After polishing,the specimens are then soaked in a solution of 10% nitric acid for 3 to 5 minutes and then cleaned and dried. At this time, defects can be seen of the polished material.

(3) An absorption method using hydrochloric acid may be utilized to examine the above mentioned defects and white spots of alloy steels.

Microscopic Analysis

2.9.4 The microscopic analysis is a process using microscopes to study in detail the composition and impurities of the materials. The polished specimen is first soaked in the solution and magnified 100 times under a microscope, and, in accordance with photos as national standards, the specimen is then determined and compared of its grade level.

(1) Crystal grains of steel. A photo is taken under the microscope and then compare with national standard photos. Those that fall within 1 to 4 grade are coarse grain; those that are in grade 5 to 8 are of fine grain.

(2) Various non-metal impurities (oxidized impurities, etc.), except of the carbon varities, can be observed under a microscope. These impurities can be classified into grades according to national standard photographs.

Non-destructive Flaw Detection

2.9.5 The objective of non-destructive flaw detection is to examine internal cracks, shrinking holes, slags, air holes and other defects of steel materials (such as important forgings and parts) through the use of x-rays, gamma rays, magnetic powder examination, luminescence examination, and ultrasonic wave examination, to determine the quality of manufactured steel products.

Chapter III Rolled Steel and Rivets for Hull Structure

Section 1 General Rules

3.1.1 Steel plates, flat steels, mold steels and other stell materials for ship hull structure should be of carbon steel and ordinary low-alloy steels.

3.1.2 Steels should be melted in electric furnaces, open-hearth or pure oxygen top-blowing rotaling furnaces; steel may also be melted with other methods with the agreements of the Ship Inspection Bureau.

3.1.3 Product quality classification should meet national standards or mechandise technical requirements. Permissible reduction of difference thickness of steel plates, flat steels, and mold steels should be in accordance with the requirements specified in Table 3.1.3.

Table 3.1.3

Plate Thickness t (mm)	Permissable Reduction Tolerances in Thickness
$t<15$	$\leqslant 0.4$mm
$t=16\sim45$	$\leqslant(0.1+0.02t)$mm
$t>45$	$\leqslant 1.0$mm

3.1.4 Steel materals are to be subdividied in lots including materials from same heat, same requirements, same rolling system, and same heat treatment. The materials in each lot are not to be more than 10 mm in thickness and are not be be more than 30 tons in weight; steel plates with a thickness equal to or less than 10 mm, each lot should not be greater than 20 tons in weight. Flat steels and mold steels measuring one meter long and weighting greater than 20 kg, each lot should not exceed 40 tons in weight; Flat steels and mold steels measuring one meter long and weighting less than 20 kg, each lot should not be greater than 30 tons in weight. Steels produced from the oxygen top-blowing rotating furnace, each lot may be composed of different heat. However, the difference in carbon contents of the furnace should not be greater than 0.03%; in manganese content not to exceed 0.15% and each lot not to exceed four furnace numbers. The weight of each lot should be the same as above.

3.1.5 Number of steel specimens are selected as follows:

(1) Chemical composition--one specimen from each heat.

(2) Tensile, cold bending (standard specimen or wide specimen) and fracture specimen, one specimen each for tensile test, cold bending, and fracture, from each batch of steel plates and mold steels at random.

(3) Impact Specimens, three selected from each lot of steel plates (or mold steel).

3.1.6 Cutting Direction of Specimens from Steel

(1) Tensile, cold bending and fracture specimens should be:

Steel plates--specimens and rolling direction should be verticle (transvese).

Mold steels--specimens and rolling direction should be horizontal (longitudinal).

(2) Impact specimens should be:

U-notch specimens--specimens and rolling direction should be verticle (transverse).

V-notch specimens--specimens and rolling direction should be horizontal (longitudinal).

3.1.7 Ship hull structure steels should have homogeneous quality; should not be laminated or l... red; should not have cracks, apparent overlaps or non-metalic impurities and other defects.
General inspection for surface quality of steel structure must be carried out. Steel plates should be examined one by one. For mold steels, plate steels, rolled steels and rivets, five specimens should be selected from each lot. They should not contain any air holes that could be seen with the naked eye; scars, cracks, or any oxizied iron scraps that had been folded or compressed into and other defects that might affect their strength.

Section 2 Carbon Steel for Hull Structure

Testing Items

3.2.1 Testing items for carbon steels for hull structure (steel plates, flat steels, mold steels) should be in accordance with requirements specified in Table 3.2.1.

Carbon Steel Testing Items Table 3.2.1

Grade of Steel	Grade I	Grade II	Grade III	Grade IV
Testing Items	1.化学成分 1 2.拉力试验 2 3.冷弯试验（标准试样） 3	1.化学成分 1 2.拉力试验 2 3.冷弯试验（宽试样） 4 4.低温冲击 5	1.化学成分 1 2.拉力试验 2 3.冷弯试验（宽试样） 4 4.低温冲击 5 5.断口组织纤维检查 7 6.奥氏体晶粒度检查 8	1.化学成分 1 2.拉力试验 2 3.冷弯试验（宽试样） 4 4.低温冲击(每张板取样) 6 5.断口组织纤维检查 7 6.奥氏体晶粒度检查 8
Equivalent steel	2 C	3 C	4 C	5 C

1 Chemical composition
2 Tensile tests
3 Cold bending tests (standard specimens)
4 Cold bending test (wide specimens)
5 Low-temperature impact
6 Low-temperature impact (specimens from each plate)
7 Fracture area fibrous structure examination
8 Austenite grain size examination

Chemical Composition

3.2.2 Chemical compostion of carbon steel for hull structure should be in accordance with the requirements specified in Table 3.2.2.

Chemical Composition of Carbon Steels Table 3.2.2

Grade of Steels	Chemical Composition (%)				
	碳 C	锰 Mn	硅 Si	硫 S	磷 P
I	≤0.22	0.35~1.3	0.12~0.35	0.05	0.045
II	≤0.22	0.4~1.3	0.12~0.35	0.05	0.045
III	≤0.20	0.5~1.1	0.12~0.35	0.05	0.045
IV	≤0.18	0.6~1.1	0.12~0.35	0.05	0.045

Mechanical Properties

3.2.3 Mechanical properties of tensile and cold bending tests of various carbon steel plates (with thickness greater than 4 mm) and mold steels for hull structure should comply with the requirements given in Table 3.2.3.

Mechanical Properties of Carbon Steels Table 3.2.3

Grade of Steels	Tensile Strength σ_b (kg/mm²)	Yield Point σ_s (kg/mm²)	Elongation rate δ_s (%)	Standard cold bending B = 2a d = 2a	Wide cold bending B = 5a d = 3a
I					
II	42~52	≥24	≥23	180° 不裂	120° 不裂
III					
IV					

Note: (1) For steel plates with a thickness ≤ 8 mm, whenever the plate thickness decreases 1mm, elongation rate may be decreased 1% (absolute value). For steel plates with a thickness ≥ 20 mm, whenever the plate thickness increases 1 mm, the elongation rate may be decreased by 0.25% (absolute value); however, when plate thickness is ≤ 32 mm, the total decrease should not more than 2%; when plate thickness is greater than 32 mm, the total decrease should not exceed 3%.

(2) For steel plates with a thickness greater than 30 mm, the wide cold bending test is not necessary; the standard cold bending test should do.

Low-temperature Impact

3.2.4 Low-temperature impact tests for grade II, III, and IV steels should be

carried out by using U-notch and V-notch specimens. Their technical specifications should comply with the requirements given in Table 3.2.4.

Table 3.2.4

Types of Specimens	Grade of Steels					
	II		III		IV	
	Temperature	Impact Toughness α_k	Temp.	Impact Toughness α_k	Temp.	Impact Toughness α_k
U-notch	−20°C	$\geq 3\ \frac{kg\text{-}m}{cm^2}$	−40°C	$\geq 3\ \frac{kg\text{-}m}{cm^2}$	−40°C	$\geq 5\ \frac{kg\text{-}m}{cm^2}$
V-notch	0°C	≥ 2.8 kg-m	0°C	≥ 4.8 kg-m	−10°C	≥ 6.2 kg-m

Note: (1) The indicated value shown in the table equals to the average value of the 3 specimens.

(2) When using the U-notch type specimens, only one of the three specimens is allowed to have a value lower than the indicated values shown in the table.

(3) When using the V-notch type specimens, if the average value of the three specimens is lower than the indicated values, but not much lower than 60%, three additional specimens selected from the same plate are allowed for impact retesting; the average value of the six specimens should satisfy the requirements of the indicated values specified in the table.

Fracture Inspection

3.2.5 Fracture inspection are required for Grade III and IV carbon steels. Width of specimens is 60 mm, length 300 mm, with a thickness equal to the thickness of the plate; the groove of the fracture is 1/3 of the width of the specimen which is cut off using the drop hammering method. The cutting surface of the specimen must have at least 30% of the fibrous structure; if the cutting surface has cracking evidence, an additional step must be taken to investigate by ramming to ascertain that the specimen does not have any laminations, impurities or other defects.

Austenite Grain Size Examination

3.2.6 Austenite grain size examination are required for grade III and IV steels, with their grain size not lower than size 5. If the steels are deoxizied with aluminum or titanium and that the grain size is assured to be greater than size 5, examination may be omitted, with the consent of the Ship Inspection Bureau.

Structural Positions and Grades of Steel

3.2.7 The grade specifications of carbon steel for hull structure are as follows:

(1) For sheer strakes, strength deck side plates, and hatch opening corner plates, when the plate thickness is 12~18 mm, grade II steel should be used; when

The plate thickness is 19~25 mm, grade III steel should be used; and when the plate thickness is greater than 25 mm, grade IV steel should be used.

(2) For strength decks, shell plates, when the plate thickness is 19~25 mm, grade II steel should be used; when the plate thickness is greater than 25 mm, grade III steel should be used.

(3) For upper and lower strakes of tanker longitudinal bulkheads, when the plate thickness exceeds 18 mm, grade II steel should be used.

(4) For masts and king posts as well as the attached mast shoulders and brackets, if the plate thickness exceeds 20 mm, grade III steel should be used.

(5) For hull structures of ships sailing in ice areas or ships operating for a long period in areas with a temperature of −10° C, grade II steel should be used. For strength decks and shell plates, grade III steel may be used with the approval of the Ship Inspection Bureau.
For hull structures of ships operating for a long period in areas with a temperature of −20° C or below, grade II steel should be used. For strength decks and shell plates and other structures, grade IV steel should be used, with the consent of the Ship Inspection Bureau.

(6) In addition to the above described requirements, other hull structures may use grade I steel; designers may use grade II and III steel according to structural positions.

Section III Low Alloy Steel for Hull Structure

Testing Items

3.3.1 Low alloy steels for ships (steel plates and mold steels) are classified into two different types. Each type is classified into grade I, III and IV according to hull structural positions; their testing items should comply with the requirements specified in Table 3.3.1.

Table 3.3.1

Grade of Steel	Grade I	Grade III	Grade IV
Testing Items	1.化学成分；1 2.拉力试验；2 3.冷弯试验（标准试样）；3 4.低温冲击（板厚≥12mm者）5	1.化学成分；1 2.拉力试验；2 3.冷弯试验（宽试样）；4 4.低温冲击；6 5.断口组织纤维检查；8 6.奥氏体晶粒度检查。9	1.化学成分；1 2.拉力试验；2 3.冷弯试验（宽试样）；4 4.低温冲击（每张钢板）；7 5.断口组织纤维检查；8 6.奥氏体晶粒度检查。9

1 Chemical composition
2 Tensile tests
3 Cold bending tests (standard specimens)
4 Cold bending tests (wide specimens)
5 Low-temperature impact (plates with a thickness ≥12 mm)
6 Low-temperature impact
7 Low-temperature impact (each steel plate)
8 Fracture area fibrous structure examination
9 Austenite grain size examination

Chemical Composition

3.3.2 All low-alloy steel for ships should be killed steel, with their chemical composition that comply with the requirements given in Table 3.3.2. If other low-alloy steel of different composition are selected for use, they should be assured to contain good weldability and with the approval of the Ship Inspection Bureau.

Chemical Composition of Low-alloy Steel Table 3.3.2

Steel Group	Equivalent Steel Group	Chemical Composition %					
		碳 C	锰 Mn	硅 Si	硫 S	磷 P	钛 Ti
Group I	16Mn	0.12~0.2	1.2~1.6	0.2~0.6	≤0.045	≤0.045	—
Group II	15Mn Ti	0.12~0.18	1.2~1.6	0.2~0.6	≤0.045	≤0.045	0.12~0.2

Note: Copper remainder amount in steel should not exceed 0.35%.

Mechanical Properties

3.3.3 Tensile tests and cold bending tests for steel plates of low-alloy steel for ships (thickness greater than 4 mm) should meet the requirements specified in Table 3.3.3.

Table 3.3.3

Tension and Cold Bending Properties of Low-Alloy Steel

Steel Group	Thickness (mm)	Tensile Strength σ_b (kg/mm²) not less than	Yield Point σ_s (kg/mm²) not less than	Elongation rate δ_s (%) not less than	Standard Cold Bending B = 2a d = 3a	Wide Cold Bending B = 5a d = 3a
Group I	≤16	52	35	21	Bendover 180 not cracking	Bendover 120 not cracking
	17~25	50	33	19		
	26~36	48	31	19		
	37~50	48	29	19		
Group II	≤25	54	40	19		
	26~40	52	38	19		

Note: (1) Yield point of low-alloy steel generally should not exceed 80% of the tensile strength.

(2) Those with thickness greater than 30 mm, wide cold bending tests may be ommitted.

Low-temperature Impact

3.3.4 Low-temperature impact toughness of low-alloy steel should meet the requirements specified in Table 3.3.4.

Table 3.3.4

Steel Groups	Type of Specimens	Grade of Steel					
		I		III		IV	
		Temp.	Impact Toughness a_k	Temp.	Impact Toughness a_k	Temp.	Impact Toughness a_k
Group I	U $\left(\frac{kg\text{-}m}{cm^2}\right)$	-20°C	≥3.0	-40°C	≥3.4	-40°C	≥5.6
	V(kg-m)	0°C	≥2.8	0°C	≥5.4	-10°C	≥6.9
Group II	U $\left(\frac{kg\text{-}m}{cm^2}\right)$	-20°C	≥3.0	-40°C	≥3.6	-40°C	≥6.0
	V(kg-m)	0°C	≥2.8	0°C	≥5.8	-10°C	≥7.4

Note: (1) The indicated value shown in the table equal to the average value of the 3 specimens.

(2) When using the U-notch type specimens, only one of the three specimens is allowed to have a value lower than the indicated values shown in the table, but should not be lower than 80% of the indicated value shown in the table.

(3) When using the V-notch type specimens, if the average value of the three specimens is lower than the indicated values, but not much lower than 85%, three additional specimens selected from the same plate are allowed for impact retesting; the average value of the six specimens should satisfy the requirements of the indicated values specified in the table.

Fracture Area Inspection, Austenite Grain Size Examination

3.3.5 Technical requirements for low-alloy steel fracture area inspection and austenite grain size examination are the same as those of carbon steel; see specifications given in 3.2.5 and 3.2.6.

Structural Positions and Grades of Steel

3.3.6 Grade specifications of low-alloy steel for hull structure are as follows:

(1) For sheer strakes, strength deck side plates, and hatch opening corner plates of strength deck, when the plate thickness is 17~25 mm, grade III steel should be used; when the plate thickness is greater than 25 mm, grade IV steel should be used.

(2) For strength decks and shell plates, when the plate thickness exceeds 22 mm, grade III steel should be used.

(3) For masts, king posts and the attached mast shoulders and brackets, when the plate thickness is greater than 18 mm, grade III steel should be used.

(4) For hull structures of ships sailing in the ice areas or ships operating for a long period of time in waters where the temperature is below -10°C, grade III steel may be used according to the structural positions, with the approval of the Ship Inspection Bureau.
For hull structures of ships operating for a long period of time in waters where the temperature is below -20°C, grade III steel should be used; for strength decks and shell plates and other structures, grade IV steel may be used, with the consent of the Ship Inspection Bureau.

(5) In addition to the above described specifications, other hull structures may be constructed with grade I steel; ship designers may also use grade III steel according to the structural positions.

Section 4 Rivet Steel

Chemical Composition and Mechanical Properties

3.4.1 Rivet rolled steels for hull structures must be of killed steels. Their chemical composition and mechanical properties should comply with the requirements given in Table 3.4.1.

Table 3.4.1

Type of Steel	Chemical Composition %			Mechanical Properties		
	硫 S	磷 P	铜 Cu	Tensile Strength σ_b (kg/mm²)	Elongation rate δ_s (%)	Hot Upsetting Test h_1/h
Carbon Steel	≤0.05	≤0.045	≤0.25	≥38	≥25	1/3
Low-alloy Steel	Equivlant property requirements of low-alloy steel for use in hull structures					1/4

Note: For rolled steels of the low-alloy group, the Ship Inspection Bureau may request a 180°, non-quenching hardness bendover test.

Number of Tests

3.4.1 Manufactured rivets may be sorted out into batches (1000 kg as one batch) to be carried out for sample testing for external inspection and measurement, using 5% of each batch (but should not be fewer than 25 rivets).

Chapter IV Steel for Boiler, Pressure Vessels, and Mechanical Structures

Section 1 Boiler Steel Plates

4.1.1 Steel plates for manufacture of boilers may be of carbon steel and low-alloy steel. Steel should be melted in open-hearth or electric furnaces. All steel plates intended for boilers must be normalized after rolling.

4.1.2 Specifications for steel plates should be in compliance with national standards or with the technical requirements specified in the mechandise invoice. Tolerences in the thickness of the steel plates should be in accordance with the requirements given in Table 4.1.2.

Table 4.1.2

Plate Thickness t (mm)	Permissable Tolerances in Thickness
$t < 15$	$\leqslant 0.4$mm
$t = 16 \sim 45$	$\leqslant (0.1 + 0.02t)$ mm
$t > 45$	$\leqslant 1.0$mm

Number of Tests

4.1.3 Each batch of steel plates should be manufactured from the same heat, made with the same rolling system with the same specification and subjected to the same heat treatment. Those with a thickness equal to or less than 20 mm, each batch should not weigh more than 30 tons; specimens are taken from any plate within each batch. Those plates with a thickness greater than 20 mm should be examined one by one, taking specimens from each plate.

Test Specimens

4.1.4 Cutting and selection of specimens of boiler steel plates:

(1) One set of standard test specimens should be taken as follows:
1 tension test specimen; 1 bend test specimen;
3 impact toughness specimens (plates with a thickness exceeding 12 mm may be omitted);
2 deformation time specimens;
1 fracture area structural homogeneity specimen (plates with a thickness under 20 mm may be ommitted).

(2) For low-alloy steel plates used for pressure vessel parts for service at elevated temperature equal to or exceeding 350° C, the manufacturing plant must select specimens to determine that the materials retaining the properties.

(3) The selection of the various specimens described above should be cut from plates transversely to the direction of rolling.

Defects

4.1.5 Boiler steel plates should be free from cracks, line slag inclusions, laminations, air holes, overlaps, and other impurities; other surface defects that do not hinder the examination, such as thin oxidied iron slags, rust, and other minute fissure are allowed, but the unsmoothness caused by these defects must not surpress the allowable tolerences.

Chemical Compostion

4.1.6 The chemical composition of boil steel plates (according to the furance in selecting the specimens) shall comply with the requirements of Table 4.1.6.

Table 4.1.6

Steel Number	Chemical Composition %							
	碳 C	硅 Si	锰 Mn	钒 V	钼 Mo	铌 Nb	磷 P	硫 S
							not less than	
20g	0.16~0.24	0.15~0.30	0.35~0.65				0.040	0.045
22g	0.19~0.26	0.17~0.37	0.70~0.90				0.040	0.045
12Mng	≤0.16	0.20~0.60	1.10~1.50				0.040	0.045
16Mng	0.12~0.20	0.20~0.60	1.20~1.60				0.040	0.045
15MnVg	0.10~0.18	0.20~0.60	1.20~1.60	0.04~0.12			0.040	0.045
14MnMoVg	0.10~0.18	0.20~0.50	1.20~1.60	0.05~0.15	0.40~0.65		0.040	0.045
18MnMoNbg	0.17~0.23	0.17~0.37	1.35~1.65		0.45~0.65	0.025~0.050	0.040	0.045

Note: (1) Copper remainder in steel should not exceed 0.35%.
(2) For retesting in chemical composition, tolerances within the specified requirements in the above table are permitted, as lisdted below:

C.....±0.02%; Mn.....±0.10%;
Si.....±0.05%; V......+0.02%;
Nb.....±0.02%; -0.01%;
Mo.....±0.05%.

Mechanical Properties

4.1.7 Mechanical properties of boiler steel plates should comply with the requirements specified in Table 4.1.7.

Table 4.1.7

Steel Number	Plate Thickness (mm)	Tensile Strength σ_b (kg/mm²)	Yield pt. σ_s (kg/mm²)	Elongation rate δ_5 (%)	Impact Value α_k (kg-m/cm²)	Deformation Time Value α'_k (kg-m/cm²)	Cold Bendover 180° d = diameter of bend a = thickness of specimens
		not less than					
20g	6~16	41	25	26	6.0	3.5	d = 2a
	17~25		24	25			
	26~36		23	24			
	37~60		23	23			
22g	6~60	43	27	24	6.0	3.0	d = 2a
12Mng	6~16	45	30	21	6.0	3.0	d = 2a
	17~25	44	28	19			d = 3a
16Mng	6~16	52	35	21	6.0	3.0	d = 2a
	17~25	50	33	19			d = 3a
	26~36	48	31	19			d = 3a
	37~60	48	29	19			d = 3a
15MnVg	6~16	54	40	18	6.0	3.0	d = 3a
	17~25	52	38	17			
	26~36	52	36	17			
	37~60	50	34	17			
18MnMoNbg	16~38	65	52	17	7.0	3.0	d = 3a
	40~95	65	50	16			
	100~115	60	45	16			
14MnMoVg	30~115	65	50	16			d = 3a

Note: The indicated impact value at ambient temperature and deformation time value equals the average value of the three specimens; the value of one of the three specimens having a lower value than the listed values in the table above is as follows:

Impact value at ambient temperature....1 $\frac{kg\text{-}m}{cm^2}$ Deformation time value....0.5 $\frac{kg\text{-}m}{cm^2}$

Fracture Area Examination

4.1.8 Specimen dimensions and documentation for homogeneity examination of fracture area structural testing are described below:

(1) Specimen dimensions----For plates 30 mm and under in thickness, the width of the specimen should be equal two times the thickness; for plates over 30 mm in thinkness, the width of specimen should be equal 1.5 times the thickness. Specimens are obtained from one side along the direction of the width to form an angular groove transversely with the plate surface; the groove depth should be 1/3 of the width of the specimen.

(2) Documentation method----Specimens are cut off using the drop hammering method. Inspect their cutting or fracture edge (if necessary, use a magnifying glass and enlarging 5 times): the metal composition of fracture surface of the specimens should be homogeneously minute, and without air holes, cracks, or other impurities. For plates under 30 mm in thickness, the fracture surface having cracks not longer than 20 mm are permitted, but individual cracks should not be exceeding 10 mm; for plates with a thickness greater than 30 mm, the fracture surface having cracks under 30 mm are allowed, but individual cracks should not be any longer than 15 mm.

High Temperature Properties

4.1.9 Specimen dimensions and testing method for high temperature properties are as follows:

(1) Specimens for tension tests at high temperature are the same as those tests at ambient temperature.

(2) During testing, specimen temperature is determined according to technical requirements concerned, but the difference in temperature should not be exceeding 5 C. Testing method and number are the same as the testing method for specimens at ambient temperature.

Flaw Detection

4.1.10 For boiler plates exceeding 40 mm in thickness made of low-alloy steel containing Mo, ultrasonic flaw detection should be carried out on each plate. Flaw detection techniques should be approved by the Ship Inspection Bureau.

Parts with Low Pressure or Low Temperature

4.1.11 Boiler components operating at low pressure under 8 kg/cm^2 and at working temperature lower than 250°C may be manufactured with Class II or Class III steel plates. Quality standards should meet the requirements specified in Section 1 and 2, Chapter III, of this Book.

Section 2 Boiler Stay Steels

4.2.1 For boiler stays, high quality, rolled carbon structural steels should be used; their chemical composition (according to furance for selecting specimens) and mechanical properties should be in agreement with the requirements given in Table 4.2.1 (a) and Table 4.2.1 (b).

Table 4.2.1(a)

Steel Number	Chemical Composition %						
	碳 C	锰 Mn	硅 Si	磷 P	硫 S	铬 Cr	镍 Ni
15	0.12~0.19	0.35~0.65	0.17~0.37	≤0.040	≤0.040	≤0.25	≤0.25
20	0.17~0.24	0.35~0.65	0.17~0.37	≤0.040	≤0.040	≤0.25	≤0.25

Table 4.2.1(b)

Steel Number	Mechanical Properties			
	Yield Point σ_s (kg/mm^2)	Tensile Strength σ_b (kg/mm^2)	Elongation rate δ_s (%)	Shrinkage rate ψ (%)
15	23	38	27	55
20	25	42	25	55

4.2.2 The surface of steels used for boiler stays should not contain any scars, overlaps, slags, cracks, and laminations and other defects which might impair their strength.

Section 3 Steels for Pressure Vessels

4.3.1 For welded pressure vessels, boiler steel plates listed in Table 4.1.6 of Section 1 of this chapter may be used. Steel quality standards should be in compliance with the requirements specified in Section 1 of this chapter; however, deformation time testing should not be carried out.

4.3.2 For Class III pressure vessels (see Book II, section 3.1.2), Grade II steel plates for hull structure may be used; quality standards should meet the requirements given in Section 1 and 2, Chapter III, of this book.

4.3.3 For seamless steel cylinders and drums, chemical composition and mechanical properties should be subject to approval by the Ship Inspection Bureau.

Section 4 Steels for Mechanical Structures

4.4.1 Rolled steels for welded structural engine supports, engine bases, cylinders, speed reduction gear boxes and other important mechanical parts should be manufactured with killed steels, containing not more than 0.24% carbon.

4.4.2 Material selection and testing requirements should comply with those described below:

(1) Selection of materials and testing requirements of important components operating at temperature above 350°C should comply with the requirements specified in Section 1 of this chapter.

Chapter 7 Steel Forgings

Section 1 General Rules

General Requirements

5.1.1 Major steel forgings for ships and machinery should be fabricated with high quality carbon steel or alloy steel.

5.1.2 Forging ratios of forgings should comply with specifications listed below:

(1) The cross-sectional area of the main body of the unmachined, raw forging ratio should not be under 3: 1 of the area of the ingot; the machined, finished forging ratio should not be under 2.5: 1; palms, flanges and similar enlargements on the forging should not be under 1.5: 1.

(2) When the forginges are made from the steel blanks, the cross-sectional area of the main body of the finished forging should not be less than 1.5: 1; flanges and similar enlargements on the forging should not be under 1.3: 1.

5.1.3 Ends of forgings should not have any piping and slacks; their surface should not contain overlaps, segregations, cracks, scars, slags, flakes, overheated evidences and other defects. Minor defects that are not injurious to the strength of the finished forgings are allowed to exist.

5.1.4 Structural defects steel blanks or forgings and non-metallic inclusions and other defects should comply with the requirements specified below:

(1) During examination, cracks that can be seen with the naked eye, non-metallic impurities, white spots, segregations, overlaps, shrinkage holes and other defects that can not be eliminated after machining are not allowed.

(2) Grades of structural defects should comply with the requirements specified in Table 5.1.4 (2):

Table 5.1.4(2)

Type	Type of Steels	中心疏松 (1)	一般疏松 (2)	方形偏析 (3)	点状偏析 (4)	皮下气泡 (5)	白点 (6)
		Not greater than (grade)					
Steel Blanks	优质碳素结构钢 (7)	3.0	3.0	3.0	3.0	2.0	0
	合金结构钢 (8)	2.5	2.5	2.5	2.5	1.5	0
Steel Forgings	优质碳素结构钢 (7)	3.0	3.0	3.0	3.0	/	0
	合金结构钢 (8)	2.5	2.5	2.5	2.5	/	0

(3) Specifications and grade of non-metallic impurities and defects should comply with requirements given in Table 5.1.4 (3).

Table 5.1.4(3)

Type	Type of Steels	氧化物 (9)	硫化物 (10)	两者之和 (11)
		Not greater than		
Steel Blanks	优质碳素结构钢 (7)	3.0	3.0	5.5
	合金结构钢 (8)	3.0	3.0	5.5
Steel Forgings	优质碳素结构钢 (7)	3.0	3.0	5.5
	合金结构钢 (8)	2.5	2.5	4.5

Note: (1) If the steel contains any nitride, list it as oxide and classify it according to oxide grade.
(2) If the steel contains any sulphate, list it as sulfide and classify it according to sulfide grade.

/These numbers correspondent to the translation in the two tables above/

1 Central slacks
2 General slacks
3 Square segerations
4 Spot segerations
5 Air bubles
6 White spots
7 high-quality carbon structural steels
8 Alloy structural steels
9 Oxide
10 Sulfide
11 Sum of the two

Test Specimens

5.1.5 Specifications for the number and selection method of testing specimens of forgings (excluding engine forgings) are as follows:

(1) For forgings weighing under 1000 kg, if several of them fabricated from the same ingot and subject to heat treatment from the same heat, 1 test sample may be obtained.

(2) For forgings weighing 1000 to 3000 kg not more than 3 m long, 1 test sample may be obtained from one end of each forging (equivlant to upper end of the steel ingot).

(3) For forgings weighing 1000 to 3000 kg and longer than 3 m, and for forgings weighing more than 3000 kg, 1 testing specimen may be obtained from each of the two ends of each forging.

(4) One set of specimen includes: 1 tensile specimen, 2 impact specimens; those forgings that are required to have a cold bending test should also have one (1) bending specimen.

5.1.6 Cutting positions of forging specimens should comply with requirements listed below:

(1) Solid round specimens should be cut 1/3 radius from the surface (refers to the blank radius of forgings); for forgings with a diameter equal to or under 50 mm, specimens may be selected from the center.

(2) Rectangular solid forgings should be cut 1/6 from the line angle.

(3) Tubular forgings should be cut 1/2 from the wall thickness.

(4) For obtaining specimen positions of certain type of special forgings, requirements may be specified on the diagrams.

Chemical Composition and Mechanical Properties

5.1.7 When using high-quality carbon steel for forgings, the grade number, chemical composition and mechanical properties after heat treatment should comply with the requirements specified in Table 5.1.7 (a), and (b).

Table 5.1.7(a)

Steel Number	碳 C (%)	硅 Si (%)	锰 Mn (%)	磷 P	硫 S	铬 Cr	镍 Ni
				Not to exceed %			
15	0.12~0.19	0.17~0.37	0.35~0.65	0.040	0.040	0.25	0.25
20	0.17~0.24	0.17~0.37	0.35~0.65	0.040	0.040	0.25	0.25
25	0.22~0.30	0.17~0.37	0.50~0.80	0.040	0.040	0.25	0.25
30	0.27~0.35	0.17~0.37	0.50~0.80	0.040	0.040	0.25	0.25
35	0.32~0.40	0.17~0.37	0.50~0.80	0.040	0.040	0.25	0.25
40	0.37~0.45	0.17~0.37	0.50~0.80	0.040	0.040	0.25	0.25
45	0.42~0.50	0.17~0.37	0.50~0.80	0.040	0.040	0.25	0.25

Table 5.1.7(b)

Steel Number	Diameter or Thickness of forgings (mm)	Mechanical Properties σ_b (kg/mm²)	σ_s (kg/mm²)	δ_5 (%)	ψ (%)	α_k (kg-m/cm²)		Cold Bendover 180° d = diameter of bend a = thickness of specimens
15	≤100	38	20	27	55	6.5		—
	101~300	35	17	25	50	6.0		
20	≤100	44	22	24	53	5.5		—
	101~300	40	20	23	50	5.0		
25	≤100	46	25	22	50	5.5		—
	101~300	43	23	20	48	5.0		
30	≤100	50	26	19	48	5.0	6.0*	d = 2a
	101~300	48	25	19	46	4.0	5.0*	
35	≤100	54	28	18	43	4.5	6.0*	d = 3a
	101~300	52	27	18	40	4.0	5.0*	
	301~500	48	25	17	35	4.0	5.0*	
	501~750	47	25	17	35	3.5	4.5*	
40	≤100	56	30	17	40	4.0	5.0*	d = 3a
	101~300	54	28	17	36	4.0	5.0*	
	301~500	50	26	17	35	3.5	4.5*	
	501~750	48	25	17	35	3.0	4.5*	
45	≤100	60	32	15	38	4.0	5.0*	d = 4a
	101~300	58	30	15	35	3.5	4.5*	
	301~500	54	28	15	35	3.5	4.0*	
	501~750	50	26	14	34	3.0	4.0*	

Note: (1) In the table above, * indicates the requirements for impact toughness for crankshafts, thrust shafts, intermediate shafts, bobbin shafts, propeller shafts, crankshafts of compressors, rudder shafts, and other important forgings.
(2) The indicated value of impact toughness equals the average value of the two specimens. Lower indicated value for one specimen of the two is allowed, but should not be lower than 75% of the indicated value.
(3) Cold bendover requirements listed in the table refers to those requiring cold bendover test (according to Table 5.3.1.

5.1.8 If alloy steel forgings are to be used, steel grade number and mechanical properties should be approved by the Ship Inspection Bureau.

5.1.9 When testing cutting direction, diametrial direction, or transverse direction of forgings, their mechanical properties should comply with the requirements specified in Table 5.1.9 according to the longitudinal reduction percentage.

Table 5.1.9

(1) 机械性能 \ (2) 试样方向	(3) 切向试验					(4) 径向或横向试验				
	σ_b	σ_s	δ_s	ψ	α_k	σ_b	σ_s	δ_s	ψ	α_k
(5) 允许降低(%)	5	5	25	20	25	10	10	35	35	40

(1) Mechanical Properties
(2) Specimen Direction
(3) Cutting Direction Tests
(4) Diametrial Direction or Transverse Tests
(5) Allowable reduction (%)

5.1.10 When cutting direction cold bendover testing is carried out for forgings, the cold bending angle may be reduced 30% comparing with longitudinal cold bendover test.

Section 2 Steel Forgings for Ship Hull

5.2.1 Number of tests for important or major forgings should be complying with the requirements specified in Table 5.2.1.

Table 5.2.1

Name of Forgings	Testing Items
Stem posts, stern posts, A-bracket, rudder stock, rudder handle, boat support	1. Chemical Composition of testing steels 2. Tensile test 3. Impact test 4. Cold bendover test (omit if not specified in Table 5.1.[illegible])

Note: Cold bendover test should be carried out no matter what ver steel grade number is used for rudder stock and rudder handle.

5.2.2 If the steel forgings for ship hull are welded together with the hull structure, those forgings' carbon contents should not exceed 0.27%.

Welding of joint-welded forgings should be subject to heat treatment.

Section 3 Steel Forgings for Diesel Engines and Shafting

5.3.1 Number of tests for important forgings should comply with the requirements specified in Table 5.3.1.

5.3.2 For crankshafts, connecting rod bolts, and thrust rings of thrust shafts, in addition to satisfying requirements specified in Table 5.3.1, non-destructive flaw detection should be carried out; tests for other forgings may be carried out if necessary.

5.3.3 Forgings with their surfaces already gone through the hardening treatment must be subject to hardness tests and non-destructive flaw detection.

Table 5.3.1

Name of Forgings	Testing Items
Bolts of diesel engine cylinders, through bolts, piston pins, cam shafts, main bearing bolts, shafting flange bolts and other major shafting transmission parts	1. Chemical compostion tests 2. Tensile tests 3. Impact tests
Upper and lower bolts for connecting rods, piston rods, crossheads, air intake valves	1. Chemical composition tests 2. Tensile tests 3. Impact tests 4. Low-multiple constitution examination 5. Metal phase analysis
Crankshafts, connecting rods, shafts of comp compressors, blades, thrust shafts, intermediate shafts, bobbin shafts, and propeller shafts	1. Chemical composition tests 2. Tensile tests 3. Impact tests 4. Low-multiple constitution examination 5. Metal phase analysis 6. Cold bending tests

Section 4 Steel Forgings for Steam Turbines and Marine Gear Boxes

5.4.1 Forgings for main shafts, solid rotors, impellers, blades, pinions, couplings, and main gear rings of steam turbines and marine gear boxes should made of steels listed in Table 5.1.7; forgings may also be made of other steels with prior approval of the Ship Inspection Bureau.

Specimens

5.4.2 Number and selection method of specimens of important forgings (such as those listed in 5.4.1) should comply with the requirements described below:

(1) For main shafts--select 1 set of longitudinal specimens from one end of the forgings; from the other end, select one (1) longitudinal tensile specimen and two impact specimens.

(2) Solid rotors--in addition to selecting specimens according to (1) above, a set of cutting specimens must be obtained from the round section of the impeller structure.

(3) Impellers--those with a diameter under 1200mm, a set of specimens must be cut from the wheel hub; those with a diameter greater than 1200 mm, one set of specimens should be obtained from the wheel hub and the rim.

(4) Blades--one batch is manufactured from the same heat and subject to the same heat treatment ; each batch should have at least 2 steel blanks selected. One tensile specimen and two impact specimens are cut from each of the blanks.

(5) Pinions--those with a diameter under 200 mm, 1 set of longitudinal specimens be cut; those with a diameter greater than 200 mm, 1 set of longitudinal specimens, 1 diametrial tensile specimen, and 2 diametrial impact specimens should be cut.

For the tooth ring of the main gear, only one set of cutting specimens should do.

(6) Shaft couplings--1 set of tangential specimens are cut.

(7) One set of specimens includes: 1 tensile specimen, 2 impact specimens, and 1 cold bendover specimen.

(8) For surface quenching forgings, the hardness of the quenching surface should be determined. The determined hardness value found in the same forging should not have a H_B tolerance greater than 30, in circumference; should not have a H_B tolerance greater than 40, in length.

Supplmentary Tests

5.4.3 Steel forgings for steam turbines and gear boxes should have supplementary tests according to the requirements described below:

(1) Acid wash examination--the neck and end of main shafts, solid rotors' impellers, impeller shells, and shaft holes should be subject to acid wash examination; their microscopic constitution should also be examined.

(2) Sulphur seal examination--forgings for main shafts, solid rotors, impellers, should be subject to sulphur seal examination during the same acid wash examination to examine sulphur segeration conditions.

(3) Heat stabilization test--solid rotors operating at temperatures above 400°C shall be subject to heat stabilization test to examine their stability under high-temperature conditions.

(4) Visual examination--center holes of turbine shafts and rotors should be subject to visual examination to inspect whether the surfaces have white spots, cracks, slacks, oxide skins, air holes and other non-metallic impurities.

(5) Remainder stress determination--impellers of composite type rotors with a diameter greater than 600 mm and impellers of solid rotors with a diameter greater than 300 mm are subject to be cut with specimens to determine the remainder tangential stress during finishing operations.

For impellers manufactured in batches, one specimen for testing is selected from every 20 impellers of the same heat.

Remainder stress σ_t may be calculated according to the equation below:

$$\sigma_t = \frac{E\delta}{D}$$

In the Equation

σ_t — remainder tangential stress, kg/mm^2;

δ — ring diameter average deformation amount, mm;

E — forging material elasticity modulus, select 20000 kg/mm^2;

D — average diameter of ring before cutting, mm.

The determined remainder stress σ_t should comply with the requirements given in Table 5.4.3 (5).

Table 5.4.3(5)

Name of Forgings		Remainder stress (kg/mm^2)
Impellers	Diameter $\leq$1000 mm	<4
	Diameter $>$1000 mm	<5
Solid Rotors	$\sigma_s \leq 50$ kg/mm^2	$\leq 0.1\sigma_s$
	$\sigma_s > 50$ kg/mm^2	$\leq 0.08\sigma_s$

(6) Ultrasonic examination--each hub surface of impellers, as well as the entire surface of main shafts and rotors should be subject to ultrasonic flaw detection after heat treatment.

(7) Magnetic particle examination--blades, pinions and gear shafts should be subject to magnetic particle examination. For those non-magnetic materials, examination may be carried out by other methods, with the consent of the Ship Inspection Bureau.

High Temperature Properties

5.4.4 For steam turbine forgings operating at temperature above or equal to 350 °C, specimens should be selected to determine the data on constant properties at high temperature.

5.4.5 For steam turbine forgins operating at temperature above 450 °C, heat-resistent alloy steels should be selected for use.

Section 5 Hot Rolled Steels

5.5.1 Intermediate shafts, bobbin shafts, propeller shafts, rudder, electric shafts and other major parts of importance that are manufactured of hot rolled steels, should be in agreement w ith the requirements described below:

(1) Chemical composition and mechanical properties of rolled steels should comply with requirements given in 5.1.7.

(2) The diameter of rolled steels should not exceed 200 mm, and should also be subject to suitable heat treatment.

(3) Manufactured products should be undergone non-destructive flaw-detection inspection.

(4) Each rolled steel is subject to tests according to the requirments specified in Table 5.3.1.

5.5.2 Types and dimension of specimens of hot rolled steels are selected according to the requirements given in Chapter II of the Book.

Chapter VI Steel Castings

Section 1 General Rules

Materials

6.1.1 Castings operating at temperature under 400° C may be manufactured with carbon steels; castings operating at temperatures above 400° C may be made of alloy steels.

6.1.2 Surfaces of castings should be smooth, should not have any air holes, cracks, shrinkage holes, cold segerations, and scars or any other defects. Minor defects that do not affect their strength may be allowed to exist. Major defects may be repaired by welding, with the consent of the Ship Inspection Bureau. Repair by welding of crankshafts should be in accordance with the requirements given in Chapter VI and Chapter VII.

Specimens

6.1.3 Selection of casting specimens should be in accord with specifications below:

(1) Specimens for diesel engine crankshafts should be casted out with the castings.

(2) Other castings may be drawn from the same heat alone.
One set of specimens includes 1 tensile specimen; 2 impact specimens; those that are required to have a cold bending test should have 1 cold bending specimen.

Chemical composition and mechanical properties

6.1.4 Chemical composition and mechanical properties after heat treatment of carbon and alloy steels should be in accordance with the requirements given in Table 6.1.4 (a) and (b). If other steels are selected for used, their chemical composition and mechanical properties should comply with the designed requirements, with the approval of the Ship Inspection Bureau.

Table 6.1.4(a)

Steel Number \ Chemical Composition	碳 C (%)	锰 Mn (%)	硅 Si (%)	钼 Mo (%)	铬 Cr (%)	硫 S (%)	磷 P (%)
ZG15	0.12~0.22	0.35~0.65	0.20~0.45	—	—	≤0.045	≤0.040
ZG25	0.22~0.32	0.50~0.80	0.20~0.45	—	—	≤0.045	≤0.040
ZG35	0.32~0.42	0.50~0.80	0.20~0.45	—	—	≤0.045	≤0.040
ZG45	0.42~0.52	0.50~0.80	0.20~0.45	—	—	≤0.045	≤0.040
ZG55	0.52~0.62	0.50~0.80	0.20~0.45	—	—	≤0.045	≤0.040
ZG25Mo	0.20~0.30	0.50~0.90	0.20~0.40	0.50~0.70	—	≤0.040	≤0.040
ZG20CrMo	0.15~0.25	0.50~0.80	0.25~0.45	0.40~0.60	0.40~0.70	≤0.040	≤0.040
ZG35CrMo	0.30~0.40	0.50~0.80	0.17~0.37	0.20~0.32	0.80~1.10	≤0.040	≤0.040

Table 6.1.4(b)

Steel Number	$\sigma_b \geq$ (kg/mm²)	$\sigma_s \geq$ (kg/mm²)	$\delta_5 \geq$ (%)	$\psi \geq$ (%)	$a_k \geq$ $\frac{kg\text{-}m}{cm^2}$	Cold bending angle $d = 2.5a$
ZG15	40	20	25	40	6.0	90°
ZG25	45	24	20	32	4.5	90°
ZG35	50	28	16	25	3.5	90°
ZG45	58	32	12	20	3.0	—
ZG55	65	35	10	18	2.0	—
ZG25Mo	50	27	20	40	4.5	90°
ZG20CrMo	47	25	18	30	3.0	90°
ZG35CrMo	60	40	12	20	3.0	90°

Note: (1) Cold bending test in the table should comply with requirements given in 6.3.1 (d is the bending diameter, a is the thickness of the specimen).
(2) The indicated value of impact toughness equals the average value of the 2 specimens. One of the two having a lower value than indicated is allowed, but should not be less than 75% of the value.

Section 2 Steel Castings for Ship Hull

Items to be Tested

6.2.1 Testing items for major steel castings are as indicated in Table 6.2.1.

Table 6.2.1

Name of Castings	Testing Items
Stem posts, stern posts, crossheads, rudder fans, and rudder handles	1. Determination of chemical composition 2. Tensile tests 3. Impact tests 4. Cold bending tests

Welding

6.2.2 Those castings that are welded by electric welding with the ship hull should not contain more than 0.27% of carbon. Major castings by welding must be subject to heat treatment.

Tests

6.2.3 After mechanical testing and surface inspection, castings for stem posts, stern posts and crossheads should then be subject to falling tests.

(1) During testing, the casting temperature should not be below 0°C, hurling the castings on a hard floor surface (1 meter thick cement) or on top of steel plate.

(2) Stern posts of solid castings may be hurled at 45° angle, letting it fall freely to floor. Other castings may be hurled from a height of 2 m; test results should not be having any cracks or breakage.

(3) For composite heavy castings, if the parts had been subject to falling tests, such castings need not be subject to the falling test.

6.2.4 After the falling test, castings should be hung; using 3 4 kg hammer and strike at the castings to inspect if there are cracks and air holes.

Section 3 Steel Castings for Machinery

6.3.1 Major castings should be subject to the testing items required by Table 6.3.1.

Table 6.3.1

Name of Castings	Testing Items
Diesel engine base, engine supports, cylinders, bearings for upper and lower connecting rods, main bearings, thrust bearings, major valve shell of steam boilers, valve shells of side valve and bottom valve, stern shaft pipes, diesel engine cylinder covers.	1. Chemical compoistion 2. Tensile tests 3. Impact tests
Propellers, crankshafts, cylinders of steam turbines, nozzle box, partition plates, gear box shells.	1. Chemical compostion 2. Tensile tests 3. Impact tests 4. Cold bending tests

6.3.2 Cold bending test for materials for crankshaft castings is conducted at an angle of 180°; bending diameter $d = 2.5a$. Manufactured products for crankshaft castings should be subject to non-destructive flaw detection inspection.

Chapter VII Iron Castings

Section 1 General Rules

7.1.1 Iron castings for ships may be manufactured with gray cast iron, nodular cast iron, or other high strength cast iron.

7.1.2 Cracks, air holes, shrinkage holes, porous spots, sand and slag granulations, and other defects are not allowed to exist in castings. Minor defects that do not affect the strength of castings may be permitted to exist. Defects of major castings may be repaired by welding with the approval of the Ship Inspection Bureau.

Section 2 Gray Iron Castings for Ships

7.2.1 Major testing items for gray iron castings should compily with the requirements specified in Table 7.2.1.

7.2.2 Testing samples of gray iron castings should be poured separately and from ladles of iron used to pour the castings, and from the same heat. Three samples each are selected for tension bending tests; types and dimensions and testing method of the samples should compily with the requirements specified in Section 8, Chapter II of this Book.

Table 7.2.1

Name of Castings	Testing Items
Diesel engine frames, engine bases, cylinder caps, sternshaft pipes	Bend resistence tests
Diesel engine cylinder blocks, pistons, guide plates, propellers	1. Hardness tests 2. Bend resistence tests
Cylinder liners, piston rings	1. Tension or bend resistance tests 2. Hardness tests 3. Microscopic inspection

7.2.3. Mechanical properties of gray-iron castings should compily with the requirements specified in Table 7.2.3.

Table 7.2.3

Gray Iron Brand Number	Tensile Resistance Strength σ_b (kg/mm²)	Bend Resistence Strength σ_w (kg/mm²)	Brinell Hardness H_B
HT 15—33	15	33	163~229
HT 20—40	20	40	170~241
HT 25—47	25	47	170~241
HT 30—54	30	54	187~255
HT 35—61	35	61	197~269
HT 40—68	40	68	207~269

Note: In the results of tension and bend resistence tests, if two of the three samples compily with the listed value specified in the Table, the castings are deemed acceptable.

7.2.4 The graphite for castings of diesel engine piston rings required for microscopic inspection should show non-directional minute particles, with their microscopic structures of perlite (among which ferrite should not exceed 5 %).

Section 3 Nodular Iron Castings

Testing Items

7.3.1 Testing items for major nodular iron castings should compily with Table 7.3.1.

Table 7.3.1

Name of Castings	Testing Items	Sample Selection Method
Diesel engine cylinder blocks, cylinder liners, pistons	1. Tension tests 2. Hardness tests	Samples are cast individually in each heat. Three tension testing samples
Shaft coupling, propellers	1. Tension tests 2. Impact tests 3. Hardness tests	Samples are cast individually in each heat Three tension testing samples Two impact testing samples

Specimens

7.3.2 Dimensions of test samples for nodular cast iron are specified below:

(1) Diameter of samples for tension testing is 10 mm, with a gage length of 50 mm; specimens with a diameter exceeding 10 mm and a gage length five times the diameter may also be used.

(2) There are two types of specimens for impact testing:

Type I--Specimens of 10mm X 10mm X 55mm, without notches and with a span of 40 mm during testing.

Type II--Specimens of 20mm X 20mm X 120mm, without notches and with a span of 70 mm during testing.

Mechanical Properties

7.3.3 Mechanical properties of nodular cast iron should compily with the requirements specified in Table 7.3.3.

Table 7.3.3

Brand	Tensile Strength σ_b (kg/mm²)	Yield Point σ_s (kg/mm²)	Elongation rate δ_s (%)	Impact Toughness a_k $\frac{kg\text{-}m}{cm^2}$	Brinell Hardness HB	Impact Test Type
	Not less than					
QT 50—1.5	50	38	1.5	1.5	187~255	Type I
QT 60—2	60	42	2.0	1.5	197~269	
QT 45—5	45	33	5.0	2.0	170~207	Type II
QT 40—10	40	30	10.0	3.0	156~197	

Note: (1) In the results of tension testing, if two of the three specimens meet the listed value specified in the Table, the castings are deem acceptable.

(2) The listed value in the table above for impact toughness is equal to the average value of two specimens. One of the two specimens with a lower value than the listed value in the Table above is permitted, but should not be lower than 75% of the listed value.

Section 4 Nodular Cast Iron Crankshafts

7.4.1. When nodular cast iron is used to fabricated crankshafts, the tensile strength of the nodular cast iron must compily with the requirements specified in Section 5.2.1 of Book II. At the same time, the various technical conditions in manufacturing crankshafts by using nodular cast iron should be approved by the Ship Inspection Bureau.

7.4.2 The following casting data for each individual or each batch of crankshafts (refers to the crankshafts cast in the same molten iron in the same heat) should be recorded for use by the Ship Inspection Bureau for examination:

(1) Pouring temperature of molten iron

(2) Chemical composition after obtaining a ferritic structure of the molten iron (the spheroidizing procedure)

(3) Temperature of molten iron during casting

(4) Time from the beginning of the spheroidizing procedure to after pouring (if the specimens are obtained from the crankshaft castings themeselves, this recording is not necessary).

Heat Treatment

7.4.3 Crankshaft castings should be subject to heat treatment to eliminate any remaining stress. If the specimens and the castings were cast separately, the specimens and the castings should be subject to the same heat treatment together.

Specimens

7.4.4 Selecting method of crankshaft casting specimens is specified below:

(1) When a batch of specimens is obtained from each nodular cast iron crankshaft, the specimens should be cut vertically at 1/3 the distance from the outer side wall of the casting head.

(2) When a batch of small-type, nodular cast iron crankshafts is cast from the same heat, specimens and castings may be cast separately, but a batch of specimens should be immediately cast after the final crankshaft casting is cast.

(3) A set of specimens include two specimens for tension test and two for impact tests. At the same time a number of specimens should be considered for retesting if needed.

(4) Specimens should be selected or cut from castings; they should all be selected with a method that does not impair the characteristics of the material.

(5) The diameter of the tension test specimen is 10 mm, with a gage length of 50 mm. Specimens with a diameter exceeding 10 mm may also be used, with a gage length equals to 5 times the diameter of the specimen.

Dimensions for the impact test specimens are 20mm X 20mm X 120mm, without notches and with a span of 70 mm.

Tests

7.4.5 Mechanical properties of nodular cast iron crankshafts after heat treatment should meet technical and designing requirements approved by the Ship Inspection Bureau. If one of the two specimens during tension and impact tests proved unqualified, another specimen should be selected for retesting; if this is deemed qualified, then the castings are considered acceptable. If the retesting is still not qualified, or the two specimens both proved unqualified during the first testing, the castings should be unacceptable and discarded. The castings are then permitted for heat treatment once again and then subject to all required testings; the acceptable ones are to be used.

7.4.6 Each individual or each batch of nodular, cast-iron crankshaft castings should be subject to metal phase inspection, their spheroidizing rate and metal phase composition should meet designing requirements.

7.4.7 Nodualar cast iron crankshafts should not have any cracks, cold shots, and other harmful defects.

Chapter VIII Steel Tubing

Section 1 Boiler Tubes and Steam Tubes

Tolerances

8.1.1 Type and grade requirements for seamless pipes for boiler and steam tubes should compily with the specifications of national standards or technical conditions specified in the purchasing order. Wall thickness tolerance of seamless pipes should compily with the requirements specified in Table 8.1.1.

Table 8.1.1

Types of Steel Pipes	Allowable Tolerance of Pipe Wall Thickness (%)	
	Ordinary Pipes	High Pressure Pipes
Hot Rolled	- 15	- 10
Cold Drawn	- 10	- 10

Note: High pressure pipes refer to boiler and steam pipes with operating pressure exceeding 60 kg/cm^2.

Testing Quantities

8.1.2 Each batch of seamless pipes should be taken from the same heat and subject to the same specification and same heat treatment; the number of each batch of copper pipes should be determined as follow:

Ordinary pipes: those with an outside diameter $\leq$ 70mm, each batch should contain not more than 400; those with an outside diameter $\geq$ 70mm, each batch should contain not more than 200.

High pressure pipes: each batch of steel pipes should not be more than 200.

External Inspection

8.1.3 The internal and external surface of the seamless pipes for boiler and steam tubes should not show evidence of cracks, cavities, scale, laminations or other surface defects. If the above mentioned defects exist, they should be completely eliminated.

The reduced thinness of the pipe wall of the portion to be eliminated should not exceed the allowable tolerance.

Testing Items and Specimens

8.1.4 After the copper pipes had been subject to external inspection, the testing items and number of specimens should be selected according to the requirements specified in Table 8.1.4.

Table 8.1.4

Type of Steel Pipes	Testing Items	Quantity of Specimens
Ordinary Pipes	1. Chemical analysis 2. Tansile test 3. Flattening test	1. Select one specimen from each heat. 2. Select two steel pipes from each batch; select from each steel pipe one specimen each for tensile test and flattening test.
High Pressure Pipes	1. Chemical analysis 2. Tensile test 3. Flattening test 4. Metal phase test 5. Impact test 6. Ultrasonic defect inspection	1. Select one specimen from each heat. 2. Select two steel pipes from each batch; select from each steel pipe one specimen each for tensile test, flattening test, and metal phase test; select 3 specimens for impact test. 3. Each steel pipe is subject to ultrasonic defect inspection.
High Pressure Joint Pipes	Same as the items for high pressure pipes	Select one lot of specimens from each steel pipe according to the testing items listed for high pressure pipes; each steel pipe should be subject to ultrasonic defect inspection.

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8.1.5 For boiler and steam pipes with a wall temperature exceeding 350 °C, specimens should also be selected to determine the high temperature instantaneous properties.

8.1.6 Steel pipes with a wall temperature under 450 °C may use seamless steel pipes made with high quality carbon steel; their chemical composition and mechanical properties should compily with the requirements specified in Table 8.1.6(a) and Table 8.1.6(b).

Table 8.1.6(a)

Steel Designation	Chemical Composition %						
	碳 C	硅 Si	锰 Mn	磷 P	硫 S	铬 Cr	镍 Ni
				Not to exceed			
10	0.07~0.14	0.17~0.37	0.35~0.65	0.035	0.04	0.15	0.25
20	0.17~0.24	0.17~0.37	0.35~0.65	0.04	0.04	0.25	0.25

Table 8.1.6(b)

Steel Designation	Tensile Strength σ_b (kg/mm²)	Yield Point σ_s (kg/mm²)	Percent Elongation δ_s (%)
10	34	21	24
20	40	25	20

8.1.7 Boiler pipes and steam pipes with a wall temperature exceeding 450 °C, may use heat-resisting alloy steel and should be delivered heat-treated. Their chemical composition, heat-treatment system, and mechanical properties should compily with the requirements specified in Table 8.1.7(a) and Table 8.1.7(b).

Table 8.1.7(a)

Steel Designation		Chemical Composition (%)												Heat Treatment System
Types	Symbols	碳 C	锰 Mn	硅 Si	铬 Cr	钼 Mo	钒 V	钛 Ti	硼 B	钨 W	稀土 Re	硫 S (Not to exceed)	磷 P (Not to exceed)	
15锰钒	15MnV	0.12 ~ 0.18	1.20 ~ 1.60	0.20 ~ 0.60			0.40 ~ 0.12					0.040	0.040	
12锰钼钒	12MnMoV	0.08 ~ 0.16	0.80 ~ 1.20	0.50 ~ 0.80		0.40 ~ 0.06	0.25 ~ 0.36					0.040	0.040	
12钼钒钨硼硅稀土	12MoVWBSiRe	0.08 ~ 0.16	0.40 ~ 0.70	0.00 ~ 0.90		0.46 ~ 0.66	0.30 ~ 0.60	*0.00	0.003 ~ 0.01	0.16 ~ 0.40	*0.16	0.040	0.040	970°~1010°C正火保温时间按壁厚每mm 1.5分钟，但不少于30分钟，760°~780°C回火，保温3小时。 (1)
12铬2钼钨钒硼	12Cr2MoWVB	0.08 ~ 0.15	0.45 ~ 0.65	0.45 ~ 0.75	1.60 ~ 2.10	0.50 ~ 0.65	0.28 ~ 0.42	0.08 ~ 0.18	≤0.008	0.30 ~ 0.55		0.035	0.035	1000~1035°C正火，保温时间按壁厚每mm1.5分钟，但不少于30分钟，760°~780°C回火，保温3小时。 (2)
12铬3钼钒硅钛硼	12Cr3MoVSiTiB	0.09 ~ 0.15	0.50 ~ 0.80	0.60 ~ 0.90	2.50 ~ 3.00	1.00 ~ 1.20	0.25 ~ 0.35	0.22 ~ 0.38	0.005 ~ 0.011			0.035	0.035	1040~1090°C正火保温时间按壁厚每mm 1.5分钟，但不少于30分钟，720°~770°C回火，保温3小时。 (3)
12铬1钼钒	12Cr1MoV	0.08 ~ 0.15	0.40 ~ 0.70	0.17 ~ 0.37	0.90 ~ 1.20	0.25 ~ 0.35	0.15 ~ 0.30					0.040	0.040	980°~1020°C正火保温时间按壁厚每mm1分钟，但不少于30分钟，720~760°C回火，保温3小时。 (4)
15铬钼	15CrMo	0.12 ~ 0.18	0.40 ~ 0.70	0.17 ~ 0.37	0.80 ~ 1.10	0.40 ~ 0.55						0.040	0.040	930~960°C normalizing, 680°~730°C tempering.

Note: (1) * Indicates the input amount

(2) Remainder copper contents should not exceed 0.25%.

(1) $970^{0} \sim 1010^{0}$ C normalizing, time for maintaining temperature according to wall thickness, each mm for 1.5 minutes, but not less than 30 min.; $760^{0} \sim 780^{0}$ C tempering, maintain temperature for 3 hours.

(2) $1000^{0} \sim 1035^{0}$ C normalizing, time for maintaining temp. according to wall thickness, each mm for 1.5 min., but should not be less than 30 min.; $760^{0} \sim 780^{0}$ C tempering, maintain temp. for 3 hours.

(3) $1040^{0} \sim 1090^{0}$ C normalizing, time for maintaining temp. according to wall thickness, each mm for 1.5 min., but should not be less than 30 min.; $720^{0} \sim 760^{0}$ C tempering, maintain temp. for 3 hours.

(4) $980^{0} \sim 1020^{0}$ C normalizing, time for maintaing temp. according to wall thickness, each mm for 1 min., but should not be less than 30 min.; $720^{0} \sim 760^{0}$C tempering, maintain temperature for 3 hours.

Table 8.1.7(b)

Steel Designation	Longitudinal Specimens 1 σ_b (kg/mm²)	2 σ_s (kg/mm²)	3 δ_s (%)	4 α_k (kg-m/cm²)	Transversal Specimens 1 σ_b (kg/mm²)	2 σ_s (kg/mm²)	3 δ_s (%)	4 α_k (kg-m/cm²)
15MnV	50	30	19					
12MnMoV	54	40	17					
12MoVWBSiRe	55	32	18					
12Cr2MoWVB	55	35	18					
12Cr3MoVSiTiB	64	45	18					
12Cr1MoV	48	26	21	6	45	26	19	5
15CrMo	45	24	21	6	45	23	20	5

1 Tensile strength 2 Yield point
3 Percent elongation 4 Impact toughness

Note: (1) When mechanical properties of steel pipes fail to meet the requirements specified in the table above, heat treatment for a second time is allowed.

(2) When the diameter and wall thickness is allowed to be cut for transversal specimens, properties may be changed to transversal properties; longitudinal properties may be omitted.

(3) For steel pipes with outside diameter $\geq$168 mm and wall thickness $\geq$25 mm, tensile resistence strength may be decreased to 4kg/mm².

(4) The listed impact toughness value is the average value of three specimens; the value of one of the three specimens is permitted to be lower than the listed value, but should not exceed 1 $\frac{\text{kg-m}}{\text{cm}^2}$.

(5) When the longitudinal properties are changed to transversal properties, the requirements of the transversal properties should be approved by the Ship Inspection Bureau.

8.1.8 Longitudinal tensile specimens may be formed into rolled or tubed specimens of equal ratio, according to the conditions of the tensile testing machine, after processing or machining. When the specimens are being rolled or machined, they should not be straightened; when the tubed specimens are used, the length of the specimens should not be greater than 300 mm.

8.1.9 **Flattening Tests:**

(1) The length of the flattening specimens should be equal to the outer diameter of the steel pipes, their maximum length should not exceed 100 mm.

(2) Flattening testing should be carried out under cold condition; after flattening, specimens should not have any cracks or breaks.

(3) After the steel pipes have been flattened, the outside plate distance from H is obtained from the following equation:

$$H = \frac{(1+\alpha)S}{\alpha + \frac{S}{D}}$$

Where
H = distance between flattening plates in mm;
S = specified wall thickness of steel tube (pipe) in mm;
a = deformation per unit length, for carbon steel 0.07;
for alloy steel 0.08;
D = specified outside diameter of tube in mm.

Hydrostatic Test

8.1.10 Each boiler tube and steam tube should be hydrostatically tested at the manufacturing mill; the hydrostatic test pressure P_s is to be determined by the following equation:

$$P_s = \frac{200S[\sigma]}{d}$$

Where
P_s = hydrostatic test pressure, in kg/cm^2;
S = minimum tube wall thickness, in mm;
$[\sigma]$ = allowable stress kg/mm^2, use 40% of the lower limit value of the tensile strength of the tubes; for high pressure tubes, use 0.85 times of the yield point.
d = specified inside diameter of the tube, in mm.

The testing pressure should be 75 kg/cm^2 in minimum; but must not exceed 400 kg/cm^2. Hydrostatic test results should be indicated in the quality certificate by the tube manufacturing mill.

Section 2 Seamless Steel Tubes and Welded Tubes for Other Purposes

8.2.1 Seamless bubes may be fabricated by using ordinary carbon steel. Their chemical composition should be ascertained to contain sulphur not to exceed 0.055%; phosphorus contents should not exceed 0.045%. Their mechanical properties should compily with the requirements specified in Table 8.2.1.

Table 8.2.1

Steel Designation	Tensile strength σ_b (kg/mm²)	Yield pt. σ_s (kg/mm²)	Percent Elongation δ_5 (%)	Steel Pipe Delivery Condition	Flattening Test
	Not less than				
A_2, AS_2, AJ_2	34	22	24	Hot Rolled	To be Carried out according to 8.1.9
A_3, AS_3, AJ_3	38	24	22	Hot Rolled	
A_4, AS_4, AJ_4	42	26	20	Hot Rolled	

8.2.2 Surface quality, allowable dimensional tolerances, and hydrostatic tests should compily with the requirements specified in Section 1 of this chapter.

8.2.3 Welded steel tube surfaces should not have cracks, scars, splits, burn spots, deep markings and other harmful defects; but such defects as pressure marks not exceeding the wall thickness tolerance as well as oxidized metal skins may be allowed to exist.

8.2.4 The mechanical properties, technical property tests and hydrostatic tests of welded steel tubes should meet the technical standards for such products.

Chapter IX Non-ferrous Metals

Section 1 Propellers

Materials

9.1.1 Copper alloy propellers (including propeller blades) may be cast with manganese bronz or high strength aluminum bronze alloys.

Testing Items

9.1.2 Testing itmes for propeller castings are as follows:

(1) Chemical analysis--specimens selected according to the ladles;

(2) Tensile tests--select one tensile specimen from each casting;

(3) External inspection--each casting should be inspected.

Specimens

9.1.3 Casting specimens are selected from the following methods:

(1) When a specimen is drawn alone, the test sample should be cast according to the cast coupons; if a casting is poured from several coupons of molten copper, each coupon of molten copper should have one specimen.

(2) If the specimen and the casting are poured together, the specimen position and its mechanical properties should be appr ..d by the Ship Inspection Bureau.

Chemical Composition and Mechanical Properties

9.1.4 The chemical composition and mechanical properties of propeller castings should compily with the requirements specified in Table 9.1.4 (a) and (b).

Table 9.1.4(a)

Types	铜 Cu (%)	锰 Mn (%)	铁 Fe (%)	锌 Zn (%)	铝 Al (%)
HMnFe 55—3—1	55~58	3~4	0.5~1.5	Remaining amount	—
ZHAl67—5—2—2	66~68	1.5~2.5	1.5~2.5	Remaining amount	4~6

Table 9.1.4(b)

Steel Designations	Tensile Strength σ_b (kg/mm²)		Percent Elongation δ_5 (%)
HMnFe 55—3—1	Sand mold	≥45	≥15
	Metal mold	≥50	≥10
ZHAl 67—5—2—2	≥62		≥12

Note: Other copper alloys, if their corrosion resistance is good and that their mechanical properties compily with the designing requirements and with the consent of the Ship Inspection Bureau, may also be used.

9.1.5 Casting surface should be of uniform grain, free from air holes, cracks, shrink holes, cold spots, scars and other defects. Minor defects that do not effect its strength may be permitted to exist. Defects of major parts may be repaired by welding, with the agreement of the Ship Inspection Bureau.

Section 2 Stern Shaft Copper Sleeves

9.2.1 Stern shaft copper sleeves may be fabricated with zinc bronze or manganese bronze. Testing itmes for castings are as follows:

(1) Chemical analysis--specimens are selected according to the ladles;

(2) External inspection--each casting shall be inspected.

9.2.2 Chemical composition of stern shaft copper sleeves should be compily with the requirements specified in Table 9.2.2:

Table 9.2.2

Types	铜 Cu (%)	锡 Sn (%)	锌 Zn (%)	锰 Mn (%)
QSn 10—2	Remaining amount	9~11	2~4	—
HMn 58—2	57~60	—	Remaining amount	1~2

9.2.3 Casting surface should not have sprues, burrs, air holes, cracks, and other defects.

Section 3 Aluminum Pistons

9.3.1 Aluminum pistons for diesel engines may be manufactured or cast with aluminum alloys. Testing items for castings are as follows:

(1) Chemical analysis--specimens are selected according to ladles;

(2) Tension tests--one specimen from each ladle, with diameter of 12 mm, gague length 60 mm;

(3) Hardness tests;

(4) External inspection--each casting should be inspected.

9.3.2 Chemical composition and mechanical properties of aluminum pistons should compily with the requirements specified in Table 9.3.2(a), (b); if other aluminum alloys are to be used also, their chemical composition and mechanical properties should compily with designing requirements and had the consent of the Ship Inspection Bureau.

Table 9.3.2(a)

Types	Si 硅 (%)	Cu 铜 (%)	Mn 锰 (%)	Mg 镁 (%)	Al 铝 (%)
Z L 3	5.0~6.5	6.0~7.0	—	0.3~0.5	Remaining amount
Z L 8	11~12.5	1~2	0.5~0.9	0.4~1.0	Remaining amount

Table 9.3.2(b)

Types	Tensile Strength σ_b (kg/mm^2)	Hardness HB	Heat Treatment
Z L 3	≥17	95~140	Aging
Z L 8	≥25	95~140	Quenching and aging

9.3.3 Casting surface should be clean, without air holes, cracks or other defects.

Section 4 Bearing Alloys

9.4.1 Bearing alloys for hull machinery may be of tin-based bearing alloys, lead-based bearing alloys, aluminum-based bearing alloys, or copper-based bearing alloys.

Testing items

9.4.2 Testing items for bearing alloys are as follows:

(1) Chemical analysis--specimens selected according to ladles;

(2) External inspection--each casting should be individually inspected;

(3) Test of the bond between the bearing alloy and base metal--each should be inspected;

(4) Microscopic analysis and hardness test--main bearings, crosshead, connecting rod top and bottom end bearings, and tri-metal thrust bearings must be subject to microscopic analysis (magnify 100 times) and hardness test. For steam and gas turbine bearing alloys, each should be subject to microscopic analysis and hardness test.

(5) Metal phase composition examination--apply only to copper-lead alloys.

Chemical Composition

9.4.3 Chemical composition of bearing alloys should be in accordance with the requirements specified in Table 9.4.3.

Table 9.4.3

Types	Sn (%)	Cu	Al (%)	Pb (%)	Al (%)
ChSnSb [illegible]	Remaining amt.	5.5~[illegible]	10~12	—	—
ChSnSb [illegible]	"	3~[illegible]	7~8	—	—
ChPbSb [illegible]	[illegible]~17	1.5~[illegible]	15~17	Remaining amt.	—
ChPbSb [illegible]	5~6	2.5~[illegible]	14~16	"	—
CPb 30	—	Remaining amount	—	27~33	—
(SOII) Tin-copper bi-metallic type	20	Remaining amount	—	—	Remaining amount

Other Requirements

9.4.4 Surface of each bearing alloy should be smooth and clean; should not contain any slags, non-metallic and other impurities.

9.4.5 Bearing alloys should be bond with the base metals.

9.4.6 For copper-lead alloys, the lead should be of medium grain and spread homogeneously on the copper base.

Section 5 Condenser Tubes and Tube Plates

9.5.1 Condenser tubes exposed to sea water may be fabricated with wrought aluminium-brass alloys.

Batches

9.5.2 Each batch of tubes should be made of the same alloy kind and subject to the same forming and heat treatment. Each batch should not exceed 1000 kg.

Testing Items and Specimens

9.5.3 Testing items and specimens for condenser tubes are as follows:

(1) Chemical analysis--specimens are selected according to ladles;

(2) Tension test--one specimen from each batch;

(3) Flattening test--two specimens from each batch;

(4) Breakage test--two specimens from each batch;

(5) Hydrostatic test--the entire batch of tubes;

(6) External examination--two specimens from each batch.

Chemical Composition and Mechanical Properties

9.5.4 Chemical composition and mechanical properties of tubes should compily with the requirements specified in Table 9.5.4(a) and (b).

Table 9.5.4(a)

Types	Cu 铜 (%)	Al 铝 (%)	Sn 锡 (%)	Zn 锌 (%)
HAl 77-2	76~79	1.75~2.5	—	Remaining amount
HSn 70-1	69~71	—	1~1.5	"
HSn 62-1	61~63	—	0.7~1.1	"

Table 9.5.4(b)

Types	Material Condition	Tensile Strength σ_b (kg/mm²)	Percent Elongation δ_{10} (%)
HAl 77-2	Soft	≥38	≥23
HSn 70-1	Semi-hard	≥35	≥30
	Soft	≥30	≥38
HSn 62-1	Semi-hard	≥34	≥30
	Soft	≥30	≥35

9.5.5 The flattening test should be carried out in cold condition; during testing, the specimens should be flattened to 35% of the original outside diameter; the flattened specimens should not have any cracks.

9.5.6 Breakage testing should be conducted as follows:

(1) Two specimen pieces should be cut from each batch of tubes, 150 mm long.

(2) Specimens should be submerged in mercury nitric solution for 2 hours.

(3) Specimens taken out of the solution should be observed, magnifying 5~10 times, and should be free of cracks.

9.5.7 Testing pressure is 50 kg/cm^2 during the hydrostatic test, for a period of 10~18 seconds. Tubes after the hydrostatic test should not leak, without cracks and deformation.

9.5.8 During external examination of tubes, their surfaces should be smooth and clean, should not have any needle holes, cracks, air holes, laminations, rust spots and other defects.

9.5.9 Cold condenser plates may be made from tin brass, lead brass, or manganese brass. Their chemical composition and mechanical properties should comply with the requirements specified in Table 9.5.9(a) and (b).

Table 9.5.9(a)

Types	Cu 铜 (%)	Pb 铅 (%)	Zn 锌 (%)	Sn 锡 (%)	Mn 锰 (%)
HPb 59—1	57~60	0.8~1.9	Remaining amount	—	—
HSn 62—1	61~63	—	Remaining amount	0.7~1.1	—
HMn 58—2	57~60	—	Remaining amount	—	1~2

9.5.9(b)

Types	Material Condition	Tensile Strength $\sigma_b \geq$ kg/mm²	Percent Elongation $\delta_{10} \geq$ %
HPb 59—1	Soft	35	25
HSn 62—1	Soft	(Hot rolled) 35	(Hot rolled) 20
HMn 58—2	Soft	39	30
HPb 59—1	Hard	45	5
HSn 62—1	Hard	40	5
HMn 58—2	Hard	60	3

Chapter X Anchors and Chains

Section 1 Anchors

Materials

10.1.1 Steel materials for anchors and parts are classified into three grades, to be used according to Table 10.1.1.

Table 10.1.1

Anchor Arrangement	Hall's Anchors and Spoke Anchors				Admiralty Anchors		Anchor Shackles	
Name of Parts	Fluke	Stock	Pinion Shaft	Hori. Locks	Anchor Body	Horiz. Stock	Body	Horiz. Locks
Steel Grades	I	II	III	II	I / II	II	II	III

10.1.2 Chemical composition and mechanical properties of steel materials for anchors should comply with the requirements specified in Table 10.1.2.

Table 10.1.2

Grade of Steel	Chemical Composition (%)					Tensile Strength	Percent Elongation	Cold Bending Angle	Equivilent Grade of Steel
	碳 C	锰 Mn	硅 Si	磷 P	硫 S	σ_b (kg/mm²)	δ_s (%)		
I	≤0.32	0.5~0.8	0.2~0.45	≤0.045	≤0.05	≥40	≥18	90°	Steel casting ZG 25
II	0.14~0.22	0.4~0.55	0.12~0.30	≤0.045	≤0.05	38~40 41~43 44~47	≥27 ≥26 ≥25	180° d = 0.5a	Common carbon Steel A_3
III	0.18~0.27	0.4~0.7	0.12~0.30	≤0.045	≤0.05	42~44 45~48 49~52	≥25 ≥24	180° d = 2a	Common Steel A_4

Specimens

10.1.3 Mechanical testing specimens for casting anchors may be drawn from the same molten steel that cast the castings, and should be fabricated from the blanks that were heat treated together with the castings. Specimens include one tensile strength specimen, and one for cold bending test. The cold bending specimen should be cut from the blanks, with a cross section surface of 20 mm x 25 mm, and a length not less than 200 mm; the corner edge may be a corner with a radius of 2 mm and a bending diameter d of 50 mm. When the selection of specimens is difficult, specimens with a cross section surface of 10 x 12.5 mm and a bending diameter of 25 mm may also be used.

Forging

10.1.4 Forged anchors and parts need only the certificate as evidence of material inspection and steel blank quality certification.

Testings

10.1.5 Stockless anchors, anchor flukes, cast anchor stocks, as well as the cast or welded anchor bodies of anchor with stocks with its respective weight (not including horizontal stocks) equal or greater than 75 kg, should be subject to the drop test.

Drop Test Heights

(1) Anchors or parts with weight <750kg----4.5m;

(2) Anchors or parts with weight equal to 750~1500kg-----4m;

(3) Anchors or parts with weight >1500kg-----3.5 m.

The specimens are to be dropped on a steel platform which is supported by a foundation on the ground.

Upon satisfactory completion of the drop test, each anchor, or its parts, if no cracks or fractures present, is to be subjected to an extensive hammering test; each piece is to be suspended freely and hammered with a suitable mallet weighing not less than 3 kg. If the parts produce a clear and resonant sound, they are deemed satisfactory. Otherwise the drop test should be repeated (or require an examination by means of an appropriate non-destructive method).

10.1.6 Upon satisfactory completion of the drop test for anchors with a mean weight $\geqq$ 75kg, a tension test should be carried out. The effective tension spot is at one side of the statutory shackle and at a distance one-third of the arm length apart from the bill, as shown in Figure 10.1.6.

In case of stockless anchors with two hinged arms, the load is to be applied simultaneously to the points of the arms and subject to the same tests.

In case of anchors with two fixed arms and with stock, the load, in the two tests, is to be applied separately to the two arms.

10.1.7 The tension test under the load for anchors should be in accordance with the requirements specified in Table 10.1.7.

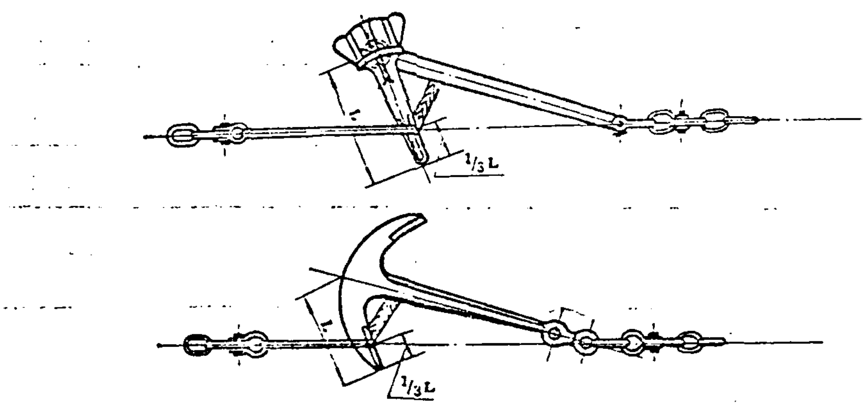

Figure 10.1.6 Tensile Tests for Anchors

Table 10.1.7

Name of Anchor	Weight of Anchor (kg)	Load (t)	Weight of Anchor (kg)	Load (t)	Weight of Anchor (kg)	Load (t)	Weight of Anchor (kg)	Load (t)
Stockless Anchor (Hall's and Speke Anchors)	75	3.4	300	8.5	900	19.3	3000	48.5
	100	4.1	350	9.5	1000	21.2	3500	54.0
	125	4.7	400	10.3	1250	25.0	4000	59.0
	150	5.4	450	11.4	1500	29.0	4500	64.0
	175	6.0	500	12.2	1750	33.0	5000	68.5
	200	6.5	600	14.2	2000	36.5	6000	76.0
	225	7.0	700	15.9	2250	40.0	7000	83.0
	250	7.5	800	17.8	2500	43.0	8000	89.0
Anchor with stock (Admiralty Anchor)	75	3.1	250	6.5	700	13.6	2000	30.6
	100	3.5	300	7.3	800	14.9	3000	41.9
	125	4.1	400	8.7	1000	17.7		
	150	4.5	500	10.5	1250	21.0		
	200	5.6	600	12.0	1500	24.2		

10.1.8 Prior to the tensioning test under the load, a punch mark is to be made on the anchor shaft and also on each bill of arms. The anchors are then subject to a preliminary 5 minute tension by a load equal to 50% of the load. The load is then reduced down to 10% and the distances between the punch marks are measured. After this the load is increased to the tensioning test value and maintained during 5 minutes. Then the load is reduced to 10% and the distances between the punch marks are measured again. The increase of the distance between the punch marks should not exceed 0.5% of the initial distance.

After the tensioning test, the free rotation of the heads of the anchors through the complete angle is to be controlled. In case the rotation of the heads is impeded or they rotate through on incomplete angle, the defects should be found and eliminated and the test repeated. If the results are unsatisfactory, the batch of anchors are worthless.

Anchors with stocks are subjected to be tension tested, with the distance between the punch marks which is measured before and after the application of the proof load which is to be applied for 5 minutes. If residual deformations are apparant, the anchors are deem worthless.

Markings

10.1.9 Upon satisfactory completion of all tests, anchors should be stamped with their respective weight and the name of the manufacturing plant, as well as the date and qualified final testing operations; the markings should be stamped both on the shank and one one of the arms, in case of stockless anchors; in case of anchors with stock, the markings should be stamped on the anchors and arms.

For anchors used in international ocean going ships, the seal of the Ship Inspection Bureau should also be stamped on them.

Section 2 Cast Steel Chains

Chemical Composition

10.2.1 Cast steel chains and their parts are fabricated with silicon manganese steel; Chemical composition of the steel should compily with the requirements specified in Table 10.2.1. Each heat of steel needs a chemical analysis.

Chemical Composition of Steel Casting Chains (%) Table 10.2.1

碳 C	硅 Si	锰 Mn	硫 S	磷 P
0.27～0.34	0.6～0.8	1.1～1.4	<0.04	<0.04

Note: Contents of copper, chromium, and nickle in the steel each should not exceed 0.3%.

External Examination

10.2.2 After careful removal of mould sand, casting heads, fissures and other defects, cast steel chain links and parts are subjected to external examination.

Harmful defects (such as air holes, slags, etc.) of each chain link should not exceed the numbers specified below:

Chain diameter d 25 46mm----4 spots
Chain diameter d 49 57mm----7 spots
Chain diameter d 62 100mm----10 spots

Defects may be repaired by welding, which is to be done before quenching. The welding should ascertain the strength and surface quality of the parts.

Chain Link Tolerances

10.2.3 Cast chain links should be examined their shapes and dimensions. Tolerances on the dimensions of chain links and parts should be in accordance with the requirements specified in Table 10.2.3(a). Tolerances for cast mould connecting surface should not exceed the requirements specified in Table 10.2.3(b).

Allowable Tolerances of Chain Links and Parts   Table 10.2.3(a)

Type of Chain Links	Chain Diameter (mm)	Allowable Tolerances		
		Chain Diameter (mm)	Chain Length	Chain Width
Ordinary Links	25~49	± 1.0	±0.1d	±0.1d
Special Enlarged Links	53~72	± 1.5		
	77~110	± 2.0		
End Chain Links	25~40	± 1.0	±0.1d	±0.1d
	43~57	± 1.5		
	62~100	± 2.0		
Connecting Chain Links	25~49	± 1.0	+0.1d −0.05d	±0.05d
	53~72	± 1.5		
	77~100	± 2.0		

Allowable Tolerances of Cast Mould Connecting Surface   Table 10.2.3(b)

(mm)

Chain Diameter (mm)	Allowable Tolerances		
	Ordinary, End	Special Enlarged	Rotating and Connecting
25~28	0.5		
31	0.5	1.0	1.0
34~49	1.0	1.0	
53~72	1.5		
77~100	2.0		

Mechanical Properties of Steel Casting Materials   Table 10.2.4

Tensile Strength σ_b (kg/mm²)	Yield Point σ_s (kg/mm²)	Percent Elongation δ_5 (%)	Percent Surface Shrinkage ψ (%)	Impact Toughness α_k (kg-m/cm²)
Not less than				
65	45	14	30	6

Mechanical Properties

10.2.4 Mechanical properties of cast steel chain materials should compily with the requirements specified in Table 10.2.4. Method of selecting specimens is to select during the casting process the blanks and chain links and after heat treated, one tensile specimen (with diameter of 20 mm, span distance of 100 mm), and two specimens for impact testing.

Cast chain links (connecting links excluded) are allowed to have their tensile strength reduced to 3 kg/mm², yield point reduced to 5 kg/mm², but at this time the percentage elongation should not be less than 16%, surface fracture shrinkage should not be less than 35%. If the mechanical property test does not deem satisfactory, twice the number of specimens should be tested again. If the retesting is again not satisfactory, the chain links and the blanks may be allowed to be heat treated together and select specimens for repeated testing.

Impact Tests

10.2.5 Impact test refers to the impact bending test to examine the quality of casting and heat treatment of anchor chains.
Impact specimens are selected from each heat one to three links for heat treatment after which for impact testing. During the impact test, one of the chain links is selected and placed on a steel platform and to be impacted for six times without any fracture. Impact moment should be in accordance with the specifications described in Table 10.2.5.

This impact test may be omitted with the agreement of the Ship Inspection Bureau if the products are stable during the fabrication in the manufacturing plant.

Proof Load and Impact Moment of Anchor Chains Table 10.2.5 .

Chain Diameter (mm)	Proof Load		Impact Moment (kg-m)	Chain Diameter (mm)	Proof Load		Impact Moment (kg-m)
	Tension (t)	Breaking (t)			Tension (t)	Breaking (t)	
25	24.8	37.2	72	57	129.1	180.6	860
28	31.1	46.7	102	62	152.6	213.5	1100
31	38.1	57.2	138	67	173.6	242.5	1380
34	45.8	68.8	180	72	191.9	268.8	1730
37	54.2	81.3	235	77	210.4	294.6	2120
40	63.4	88.9	300	82	228.2	319.2	2560
43	73.4	102.8	370	87	245.0	343.0	3050
46	84.8	117.6	450	92	260.5	364.8	3600
49	95.2	133.4	545	100	282.8	395.8	4640
52	111.1	156.1	690	—	—	—	—

Breaking Test

10.2.6 Upon the satisfactory completion of the impact test, a breaking test for anchor chains and parts (end links, rotation links, connecting links, connecting shackles, etc.) should be carried out. Each breaking test sample is to be made up of three links of chain. The breaking load shall be applied to at least one item out of every batch of joining or connecting links, swivels and end cast links and end shackles of the same production technique and same heat, with the same diameter, consisting of not more than 50 similar parts and components as one batch.

For breaking test of welded chain lengths one 3-link sample is to be selected from each chain lengthstaken from a batch of chain lengths of the same diameter and the same cast and having been heat treated in the same furnace charge.

The tests are to be carried out on testing machines performing slow and steady increase of the load applied to the sample until the specimen is broken. The breaking load of the specimen should exceed those breaking loads specified in Table 10.2.5. If the load of the specimen exceeds the required load and does not break, then the specimens are deem satisfactory.

Upon satisfactory completion of the testing, the chain links of various heat may be used to form new groups of anchor chain links.

Tensile Test

10.2.7 Upon satisfactory completion of the breaking test, anchor chain links and parts are subjected to a tensile test according to the loads specified in Table 10.2.5.

During the tensile test, tension is gradually put on the proof load to 20%, and then measure the length of the chain lengths. The tension is then gradually extended to the required load for 5 minutes, after which the load is reduced to 20% of the tension; at this time remeasure the length of chain lengths, and compare with the first measurement. When the diameter of the chain $d \geq$ 43mm, the percentage elongation should not exceed 2.5%; when the chain diameter $d \leq$ 43mm, its percentage elongation should not exceed 3 %.

The breaking number of chain links during tensile test should not exceed three.

All chain lengths and details having passed the tensile test shall be subjected to visual inspection and measurement; chain link surfacess should be free of cracks and other defects

Markings

10.2.8 All chain lengths, rotation links, end shackles, join shackles, and join links, in addition to be stamped with the testing load, date and manufacturing plant, should also be stamp with the seal of the Ship Inspection Bureau, if the chains and their fittings are used for international ocean going ships.

Section 3 Electrically Welded Chains--Anchor Chains, Rope Tools, Chains and Rudder Chains

Chemical Composition and Mechanical Properties

10.3.1 Chemical composition and mechanical properties of rolled steels used in electrically welded anchor chains and links and other fittings should comply with the requirements specified in Table 10.3.1

Table 10.3.1

Name of Parts		Chemical Composition%					Mechanical Properties				Equivalent Steel Grades
		碳 C	锰 Mn	硅 Si	磷 P	硫 S	σ_b (kg/mm²)	σ_s (kg/mm²)	δ_s (%)	180°	
(1) 电焊有档和无档普通链环，加大链环，末端链环 锻造转环和锻造脱钩的链环		0.12 ~ 0.18	0.3 ~ 0.55	≤0.15	≤0.035	≤0.04	37—45		≥24	d = 0	
(2) 锚端卸扣的本体和横销、无螺纹转环的环栓、脱钩的钩和楔以及卸扣和连接链环的圆锥销、连接链环的半链环和横销							42~52	≥24	≥23	d = 2a	A4
(3) 带螺纹转环的环栓和螺母							50~62	≥26	≥19	d = 3a	A5
Horizontal bars of ordinary and extra large chain links	Mould Pressure						34~42	≥20	≥25	d=0.5a	A2、A3
	Casting						12	Bend Resistance Strength 28			HT12—28
							15	Bend Resistance Strength 33			HT15—33

(1) Electrically welded stud and studless chain links of ordinary kind, extra large size chain links, end links; forged rotation links and forged studless chains.

(2) Body and horizontal locks of end shackles, non-screw rotation links and link pegs, turnbuckles, round locks, studs, and shackles and join links; half links and orizontal locks of join links.

(3) Link pegs and nuts of screw-type rotation links.

Specimens

10.3.2 Specimens for rolled steels used in welded chain links should be divided according to groups of the heat, with each group with not more than 100 rolled steels of same diameter not greater than 3 mm. Each group of rolled steels should have one tansile test specimen, and one cold bending specimen.

Materials and Welding

10.3.3 All rolled steels used for welded chains should be subjected to external examination; and should not have any cracks, scars, lamintations, and other defects. Allowable tolerance of the diameter of rolled steels should compily with the requirements specified in Table 10.3.3.

Table 10.3.3

Rolled Steel Diameter (mm)	5~19	22~25	28~49	53~62
Allowable Tolerances (mm)	+0.4 -0.1	+0.5 -0.1	+0.6 -0.1	+0.7 -0.4

10.3.4 Links of each chain lengths should be fabricated from the same type of materials. Links should be contact welded or arc welded.

(1) Contact welding should not have any slags, overheated metal and burned spots, and should be thoroughly welded.

(2) Arc welding should be thoroughly welded and should not have any air holes, slags, fissures, and arc grooves and other defects.

The welded materials should be heat treated.

10.3.5 During welding of anchor chain links, the correspond location of each half link should not exceed the requirements specified below:

Chain diameter $d=5\sim 8$ mm----0.5mm
" " $d=9\sim 15$ mm----0.8 mm
" " $d=17\sim 22$ mm----1.0 mm
" " $d=25\sim 37$ mm----1.5 mm
" " $d \geq 40$mm----2.0 mm

After the chains are welded, the longitudinal surface's flexiablity should be: when chain diameter $d<37$ mm, it should not exceed 1 mm; when chain diameter $d=40\sim 53$ mm, it should not be exceeding 1.5 mm; when chain diameter $d\geq 57$ mm, it should not exceed 2 mm.

The welded chains and links and other fittings should be subjected to dimensional measurement; their allowable dimensional tolerances should meet the requirements specified in Table 10.3.5.

Table 10.3.5

Chain Diameter d (mm)	Allowable Tolerances	
	Chain Length and Width	Diameter Tolerances at Bending Point (mm)
5—9	±0.1d	-0.5
11—15		-0.6
17—22		-0.7
25—49		-1.0
53—67		-1.5

10.3.6 Upon welding of chains, a breaking test should apply to test the short links; its testing method is as follows:

(1) Chain lengths with standard length (25 m) and a diameter $d < 13$ mm, one specimen consists of 5 links for each chain length is selected; when the diameter $d \geq 13$ mm, one specimen consists of 3 links is selected.

(2) Undivided, studless chains should have one 5-link specimen for each 50 m.

(3) For single length chains with a length smaller than the standard length, specimens may be selected from each group of lengths made of the same materials and same technique. When the chain diameter $d < 13$ mm, select one 5-link section for each 50 m; when $d \geq 13$ mm, select one 5-link for each 25 m.

Breaking test is to be carried out on testing machines performing gradual, homogeneous increase of the load applied to the sample, until breakage. The breaking load of the specimen should exceed the breaking loads specified in Table 10.3.6(3).

During testing, only part of the specimens are subjected to breaking load on the testing machine up to destruction of the specimens, the number of which should not be less than 5 % of the total specimens. Other specimens after testing that do not break shall be deem acceptable.

Table 10.3.6(3)

Chain Diameter (mm)	Close-link Chains Proof Load Tension (t)	Close-link Chains Proof Load Breaking (t)	Open-link Chains Proof Load Tension (t)	Open-link Chains Proof Load Breaking (t)
5	—	—	0.32	0.64
6	—	—	0.50	1.00
7	—	—	0.80	1.60
8	—	—	1.20	2.40
9	—	—	1.55	3.10
11	—	—	2.30	4.60
13	4.60	7.00	3.20	6.40
15	6.20	9.40	4.30	8.50
17	8.10	12.20	5.50	10.90
19	10.20	15.30	6.80	13.60
22	13.80	20.60	9.20	18.30
25	17.70	26.60	11.80	23.60
28	22.20	33.30	14.80	29.60
31	27.20	40.80	18.20	36.30
34	32.70	49.10	21.90	43.70
37	38.70	58.10	25.90	51.80
40	45.30	63.50	—	—
43	52.40	73.40	—	—
46	60.00	84.00	—	—
49	68.00	95.30	—	—
53	78.80	111.00	—	—
57	92.20	129.00	—	—
62	109.00	152.00	—	—

Tensile Test

10.3.7 Upon the completion of the breaking test, each chain length is subjected to the tensile test. Tensile test load should be in agreement with the requirements specified in Table 10.3.6(3). Testing method is the same as described in Section 10.2.8. However, the percentage elongation of each anchor chain length, when the chain diameter d $\geq$ 43 mm, should not exceed 2.5%; when the diameter d < 43 mm, the percentage elongation should not exceed 3 %.

During tensile testing, if the chain lengths break, continue the testing with a connecting piece jointed to the breaking location. After testing, conduct a thorough visual inspection. If the breakage occurs at the welding point of the chain length and exceeds three, the anchor chains are then deem unacceptable and worthless. If the breakage does not exceed three at the welding point, a new test of another chain link may be repeated; the retest should not yield any breakage.

Markings

10.3.8 Upon satisfactory completion of the test, welded chains should be stamped according to the requirements specified in 10.2.8.